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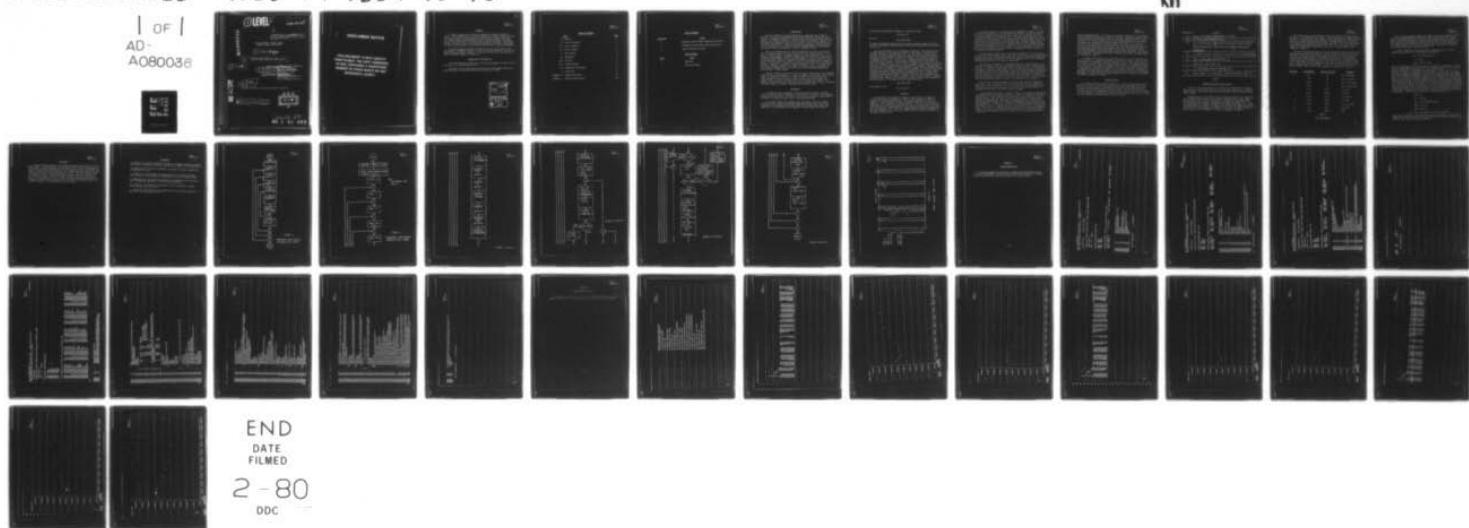
NAVAL UNDERWATER SYSTEMS CENTER NEWPORT RI  
COMPUTER AIDED PARAMETRIC SONAR DESIGN.(U)

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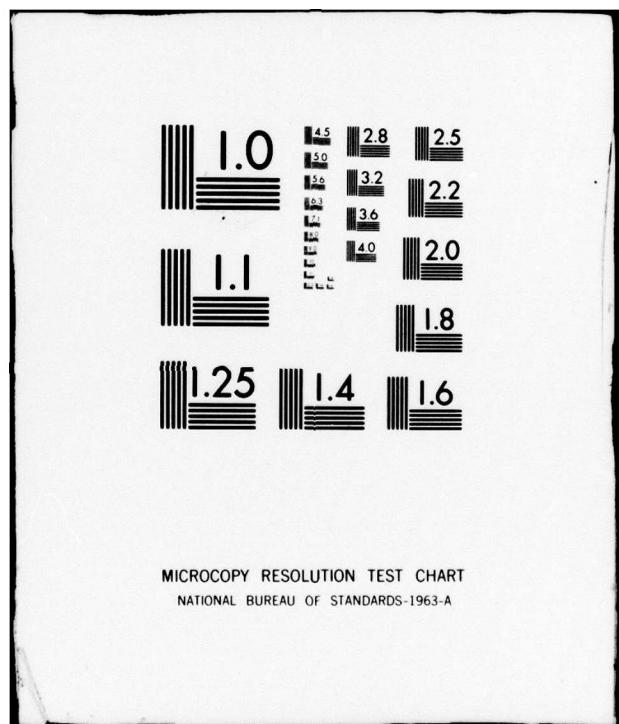
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NAVAL UNDERWATER SYSTEMS CENTER  
Newport, Rhode Island 02840

⑨ Technical Memorandum

⑥ COMPUTER AIDED PARAMETRIC SONAR DESIGN

⑪ 23 May 73

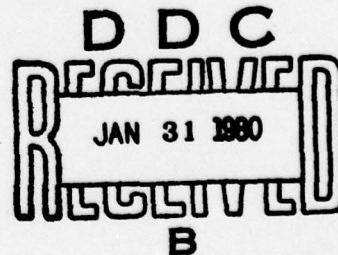
Prepared by Edmund C. Passow  
Edmund C. Gannon,  
Parametric Sonar Group  
Robert P. Pingree  
A. J. Van Wervkum  
Robert P. Pingree  
R. P. Pingree  
Digital Computing Division

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### ABSTRACT

A computer program was written that enables the design of parametric sonars. This program accepts as inputs temperature, salinity, depth, estimates of projector area, desired secondary source level and secondary frequency. The program computes various parametric sonar quantities among them primary source level, directivity index and primary operating frequency. The program actually generates a matrix of possible design values that permit the designer to choose those which best suit his needs based on other system considerations.

The design program is written in Fortran V for use on the Univac 1108. The program is completely general and any of the input parameters can be varied while holding the others constant. A discussion on how to use the program as well as a sample example is included.

### ADMINISTRATIVE INFORMATION

This memorandum was prepared under Project No. A-614-19, Principal Investigator, Dr. A. J. Van Woerkum, Code TC.

The authors of this memorandum are located at the New London Laboratory, Naval Underwater Systems Center, New London, Connecticut 06320.

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## INTRODUCTION

From the viewpoint of the individual who is faced with the design of a parametric sonar, the calculations involved seem repetitive and in some cases endless. The Mellen and Moffett<sup>1</sup> curves together with the appropriate equations given in the reference contain all of the necessary information. However, the information is presented in such a way as to make it easy to work through the curves and calculations to analyze the parametric operation of existing projectors and systems but it is difficult and not straightforward to work backward through the curves and equations to design a projector system.

There is a solution which is offered by Moffett<sup>2</sup> that uses a "load line" type of technique similar to that used in vacuum tube circuit design. This is good for a small number of possible designs of a given parametric sonar. The method requires, however, repetitive computations to arrive at the dimensionless parameters  $1/(2)(AL)(RO)$  for each possible parametric stepdown ratio (the ratio of the parametric difference frequency to the mean projector driving frequency  $FO/F$ ). The term  $(AL)$  is absorption in nepers per meter while  $RO$  is the Rayleigh distance. Appendix B contains a complete glossary of terms. The "load line" method is presently limited by the number of families of curves available for the different stepdown ratios and the accuracy of interpolating between the given curves of a given family.

A means, therefore, was devised where the whole design process was automated using the Univac 1108 computer. In essence, computer aided design. The solution allows the designer to work from a known secondary source level (LSS) and a known secondary frequency (F) for a range of values of projector size (A), primary source level per tone (LSP) and a given stepdown ratio ( $FO/F$ ). The computer program will build a matrix of possible designs that can then be compared with other factors to achieve a workable and realistic design.

## BACKGROUND

In parametric sonar calculations, two distinct and different problems arise. One is that of the analysis of existing sonar to predict their parametric operating characteristics. The other is the design of parametric sonars having a given set or range of output source levels and frequencies.

In the first problem, one usually knows the primary operating frequency ( $FO$ ), the primary source level (LSP), and the projector area (A). From these one obtains the secondary source level (LSS) and secondary directivity index (NDIS) for a given downshift ratio ( $FO/F$ ) by using the Mellen and Moffett

curves and the appropriate formulae. In summary, we know

FO, LSP and A.

We find

LSS, FO/F, NDIS.

The Mellen and Moffett curves and the associate equations readily lend themselves to solving this problem because of the way the equations and the curves are set up.

The second problem is one of designing a parametric sonar starting from "scratch" where one only knows the desired, or the range of desired, LSS, F, and NDIS and wants to find FO, LSP and A. At first glance one would say, "Why not just work backwards through the equations with the aid of the Mellen and Moffett curves?" Alas, life is not so simple. The equations depend on a knowledge of FO, and A. In other words, something must be known about the projector before starting. Unfortunately, determining FO, A, and LSP is the goal of the design process. This is just the opposite of the analysis previously discussed. There is a method that has been proposed by Moffett that utilizes the "load line" technique previously mentioned. This method is excellent when an exact FO and A are sought for a given LSS, F, and NDIS. The method becomes time consuming and requires tedious repetitive calculations when a range of values is sought and when one needs numerous possibilities in order to examine and choose an optimum solution based on factors other than just parametric sonar considerations. What is needed is a method of constructing a matrix of possible parametric sonar designs for the designer to weigh in consort with associated system parameters. In summary for this situation we know

LSS, FO/F, NDIS

and we want to find

FO, LSP and A.

#### SOLUTION

The solution to the problem is computer aided design. A program was written that allows the designer to vary F, A, LSS, and FO/F in order to construct the desired design matrix. The program compilation is given in Appendix A. This program is versatile enough so that three other parameters temperature (T), salinity (S) and depth (D) can be varied in coarse steps and their effects on the design studied. The results are tabulated and two on-line plots are possible. The results of a sample example are shown in Appendix B. The on-line plots can be of any two variables and each plot can be altered by changing a computer card.

At present, one plot is acoustic power in dB (PADB) vs. FO/F for a given LSS with the parameters T, S, D, F and A held constant. Then either LSS, F, or A can be changed and another plot made. Thus, one can examine the range of possible designs that are within the desired power budget and select a reasonable one. The second plot is secondary directivity index (NDIS) vs FO/F for the same given conditions as in the previous plot. From this the designer can select the necessary quantities for a desired range of NDIS. Normally, many plots will be produced resulting in families of LSS curves with NDIS and PADB plotted against FO/F with T, S, D, constant for many combinations of F and A. Once a set of parameters is decided upon, the appropriate exact constants can be obtained from the tabulation.

One thing that has been done to aid in plot comparisons is to force the plots to a convenient common scale. This was done by the use of two dummy points on each plot. This was necessary because the routine as originally compiled by Gordon<sup>3</sup> automatically scaled the axis for the plotting range. For the desired comparisons of plots, such scaling is undesirable.

The program is outlined in a simplified flow chart shown in Figure 1. It operates as follows: The inner loop computes parametric sonar design constants for each of a sequence of FO/F values. This is done for each of a sequence of LSS values in the input data (LSS1). Next, the two inner loops are repeated for a sequence of values for A and finally these three innermost loops are repeated for each value of F in the input data. These four loops generate a matrix of possible designs for the ranges of FO/F, LSS, A, and F chosen. Each matrix is built up for constant values of T, S, and D. The values for T, S, and D can be altered by changing them when the data is programmed into the computer.

The plots as presently compiled plot after each sequence of FO/F for a given LSS. Thus, a family of curves of different LSS values is generated. These are for each combination of T, S, D, F, and A and are plotted with FO/F as the horizontal axis on each plot. The vertical axis on plot number 1 is PADB while the vertical axis on plot number 2 is NDIS.

A more detailed flow chart is shown in Figure 2. It shows an expansion of the computational block diagram of Figure 1. Thus, the location of the various calculations are shown along with the appropriate tests required to keep the program bounded. Once the data is entered, the calculations leading to the quantity  $1/(2)(AL)(RO)$  are made where the attenuation loss is (AL) and the Rayleigh distance is (RO). This quantity  $1/(2)(AL)(RO)$  together with the FO/F and a quantity X is entered into a numerical integration subroutine devised by Goldstein<sup>4</sup>. The X is a parameter that ties the integration to a scaled source level ( $L^*$ ) which is a normalized parametric quantity in the Mellen and Moffett theory. The output of the numerical integration enters into several simple computations, the results of which are tested to see if they fall within the

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proper programmed bounds. If the tests are failed, a new value of X is chosen and the integration routine is redone and retested. Depending on how the tests are passed, the program either proceeds to calculate further parametric sonar quantities for the given solution of the numerical integration or the program recognizes that the numerical integration has searched as far as it can. In any event, the program will proceed to readout the results in a table then recycle to the next FO/F in the innermost loop. Once the desired LSS values has been completely investigated, the computer constructs the two on-line plots previously mentioned. The program then recycles until all possible values of F, A, LSS and FO/F have been investigated and all plots completed. The program then terminates. The detailed flow chart (Figure 2) references equations which are tabulated in Table I.

In essence, the program takes some known values for a given condition and hunts, by means of a numerical integration routine and specific tests, for other needed values to completely describe a parametric sonar. Since usually there is a range of desired values, the program builds a matrix of possible solutions. The accuracy of these solutions depends on the accuracy of the parameter X used in the numerical integration. Presently, the solution calculates an LSS which is compared with the input LSS (LSS1). The calculated value has a tolerance of  $\pm 0.82$  dB. The resultant LSP, parametric gain (G), acoustic power (PA and PADB), and primary frequency directivity index (NDIP) all have a tolerance of  $\pm 0.41$  dB. The NDIS has a  $\pm 0.82$  dB tolerance.

#### PROGRAM OPTIONS

The design program has certain options as a result of the general form in which it is written. The program contains four nested loops any of which can be varied or held constant by appropriate input data on the input data cards. The plots can be varied, however, this may involve repositioning the plot in the program as well as changing two program cards. The user may have to redimension the storage associated with the loops preceding the plot in order to be sure the data computed is retained until the plot is called.

Equation No.	Equation
1.	$X_{(I+1)} = 1.1X_I$ FOR 86 VALUES FROM $X = 0.090909$
2 <sup>5</sup> .	$FT = 21.9 \times 10^6 - (1520/(T+273))$ kHz
3 <sup>5</sup> .	$AL = (1/8.68)(1/914.4) \left\{ \left[ (1.86 \times 10^{-2})(S)(FT)(FO)^2 / [(FT)^2 + (FO)^2] \right] + \left[ 2.68 \times 10^{-2}(FO)^2 / FT \right] + \left[ 0.1(FO)^2 / (1 + (FO)^2) \right] \right\} (1 - 6.33233 \times 10^5 D)$ NEPERS/METER
4 <sup>5</sup> .	$C = 1449.2 + 4.623T - 0.0546(T^2) + 1.391 (S-35) + 0.017D$ METERS/SECOND
5 <sup>6</sup> .	$NDIP = 10 \log_{10} (4\pi A (FO)^2 (10^3)^2 / C^2)$ DB
6.	$PADB = LSP - 70.8 - NDIP$ DB
7.	$PA = \text{ANTILOG} \left[ (1/10)(LSP-70.8-NDIP) \right]$ WATTS
8 <sup>1</sup> .	$NDIS = (NDIP) + 3 - 10 \log_{10} \left[ 1 + ((FO)/F)(2\pi (AL)(RO) + X) \right]$ DB

TABLE I

PROGRAM USAGE AND SAMPLE EXAMPLE

In order to use the program, the user must stack appropriately formatted data cards in a fixed order at the end of the program. There are six different types of cards. These cards will now be discussed in order from front to back of the stack.

The first type of card contains only one card and comes first in the data. It is formatted into 4 fields of one integer number per field. Each number must be right justified in a field width of five (Fortran V statement (I5)). The first field uses columns 1 through 5 and contains the number of F values. The second field uses columns 6 through 10 and contains the number of A values. The third field uses columns 11 through 15 and contains the number of LSS values. The fourth field uses columns 16 through 20 and contains the number of FO/F values plus 1. This arrangement of fields is summarized in Table 2.

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The second type of card contains only one card and it is the 2nd card in the data. It is formatted into 3 fields. Each field contains a number that is written in a floating point format which is right justified in a field width of 10 with a 4 decimal place accuracy (Fortran V statement (F10.4)). The first field uses columns 1 through 10 and contains the value for T. The second field uses columns 11 through 20 and contains the value for S. The third field uses columns 21 through 30 and contains the value for D. These fields are also summarized in Table 2.

The third through sixth type of cards may contain more than 1 card for each type but only one value for each card. Thus, one must use as many cards for each type as there are values associated with that type and the cards for each type must be grouped together. Each number is written in a floating point format which is right justified in a field width of 10 with a 5 decimal place accuracy (Fortran V statement (F10.5)). Each third type of card gives a value for F. Each fourth type of card gives a value for A. Each fifth type of card gives an input value for LSS (LSS1). Lastly, each sixth type of card gives a value for FO/F. Each of these field layouts are summarized in Table 2.

<u>Card Type</u>	<u>Card Columns</u>	<u>Fortran IV Format</u>	<u>Agreement</u>
1	1-5	I5	No. of F values
	6-10	I5	No. of A values
	11-15	I5	No. of LSS values
	16-20	I5	No. of FO/F values
2	1-10	F10.4	T in deg C
	11-20	F10.4	S in PPT
	21-30	F10.4	D in meters
3	1-10	F10.5	F in kHz
4	1-10	F10.5	A in sq. meters
5	1-10	F10.5	LSS in dB
6	1-10	F10.5	FO/F

TABLE 2  
DATA CARD FORMATS

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The use of this program requires the input of data from a program stored on tape in the NUSC New London Laboratory Univac 1108 files. This is tape U183. Different parameter plots may be made by simply changing the call to plot (Call Plot A) statements. There are two such plots in the program. The plot routine can be eliminated by removing the two call to plot cards which are located adjacent to each other in the program. The rest of the program should run and the table of results printed.

A sample example will now be discussed. Suppose we want to design a parametric sonar that has the following specifications:

$$LSS = 90 \text{ dB}/1\mu\text{bar-meter}$$

$$F = 3 \text{ kHz}$$

$$N_{DI} = 30 \text{ dB to } 35 \text{ dB}$$

and the power budget is such that we wish to minimize its consumption. Assume that the system will work in the ocean ( $S = 35 \text{ ppt}$ ) and that the system must be capable of operating in the winter ( $T = 7^\circ\text{C}$ ) on the surface ( $D = 0$ ). The data is programmed as shown in Figure 3. The tables of results are shown in Appendix B along with 3 sets of plots. Examination of the results shows several design possibilities all within the region of a dip in the PADB plots. If it were not possible to examine so large a quantity of points, the dip quite possibly would go unnoticed because there is a tendency for the unwitting designer to assume that increased stepdown ratio means increased power consumption. Apparently, this is not always true. When the desired points are isolated on the plots, the designer then can go to the tables and from them he can determine the design that gives the desired source level within the NDIS restrictions. The desired design for the sample example is the one underlined in the appropriate table of Appendix B and encircled on each of the associated PADB and NDIS vs FO/F plots. The selected design has the following parameters:

$$FO/F = 10$$

$$FO = 30 \text{ kHz}$$

$$LSP = 131.2 \text{ dB}/1\mu\text{bar-meter}$$

$$NDIP = 36.1 \text{ dB}$$

$$NDIS = 34.4 \text{ dB}$$

and  $PA = 267.1 \text{ watts/each primary frequency.}$

Other related quantities can be obtained from the data tables. For different applications these quantities may assume importance and thus are readily available if design tradeoffs become necessary.

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#### CONCLUSION

A computer aided parametric sonar design program has been written for the UNIVAC 1108. This program allows the designer to take a given secondary source level (LSS), secondary frequency (F) and secondary directivity index (NDIS) and compute a range of possible parametric sonar designs that will satisfy his needs. Thus, the selection of sonar parameters is no longer limited by the difficulty of examining a range of possible parametric designs. The sonar designer can now construct a matrix of possible designs then base the final selection on which of these designs best fits the other systems parameters being considered. By means of computer aided design, literally hundreds of possible designs for a given situation can be investigated in a short time.

REFERENCES

1. Mellen, R. H. and M. B. Moffett, "A Model for Parametric Radiator Design," USN Journal of Underwater Acoustics, Vol. 22, No. 2, April 1972 (Unclassified).
2. Moffett, M. B., "Load Line Technique for Parametric Design," unpublished communication in 1972.
3. Gordon, R. L., "A Fortran V Plotting Routine for the Univac 1108 High Speed Printers," USL Tech Memo No. 2242-291-68, 25 July 1968 (Unclassified).
4. Goldstein, M., "On A numerical Integration in Parametric Sonar Research," NUSC Tech Memo No. PA4-268-71, 21 Oct 1971, (Unclassified).
5. Urick, R. J., "Principles of Underwater Sound for Engineers," McGraw Hill, Copyright 1971, pages 88-96.
6. "The Design and Construction of Magnetostriction Transducers," NDRC Div 6 Report Vol. 13, dated 1946, p. 128.

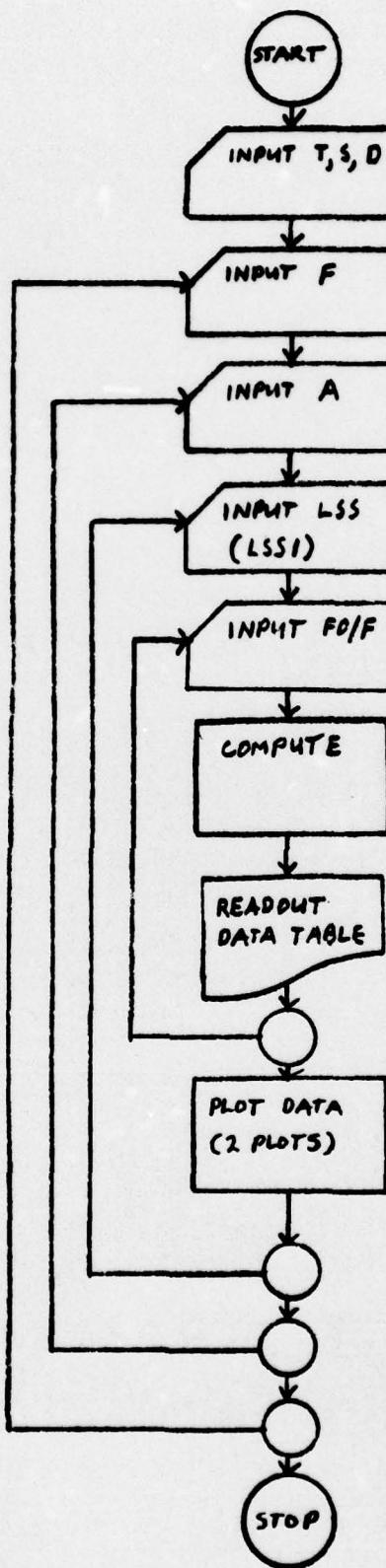


FIGURE 1  
PARAMETRIC SONAR DESIGN,  
SIMPLIFIED FLOW CHART

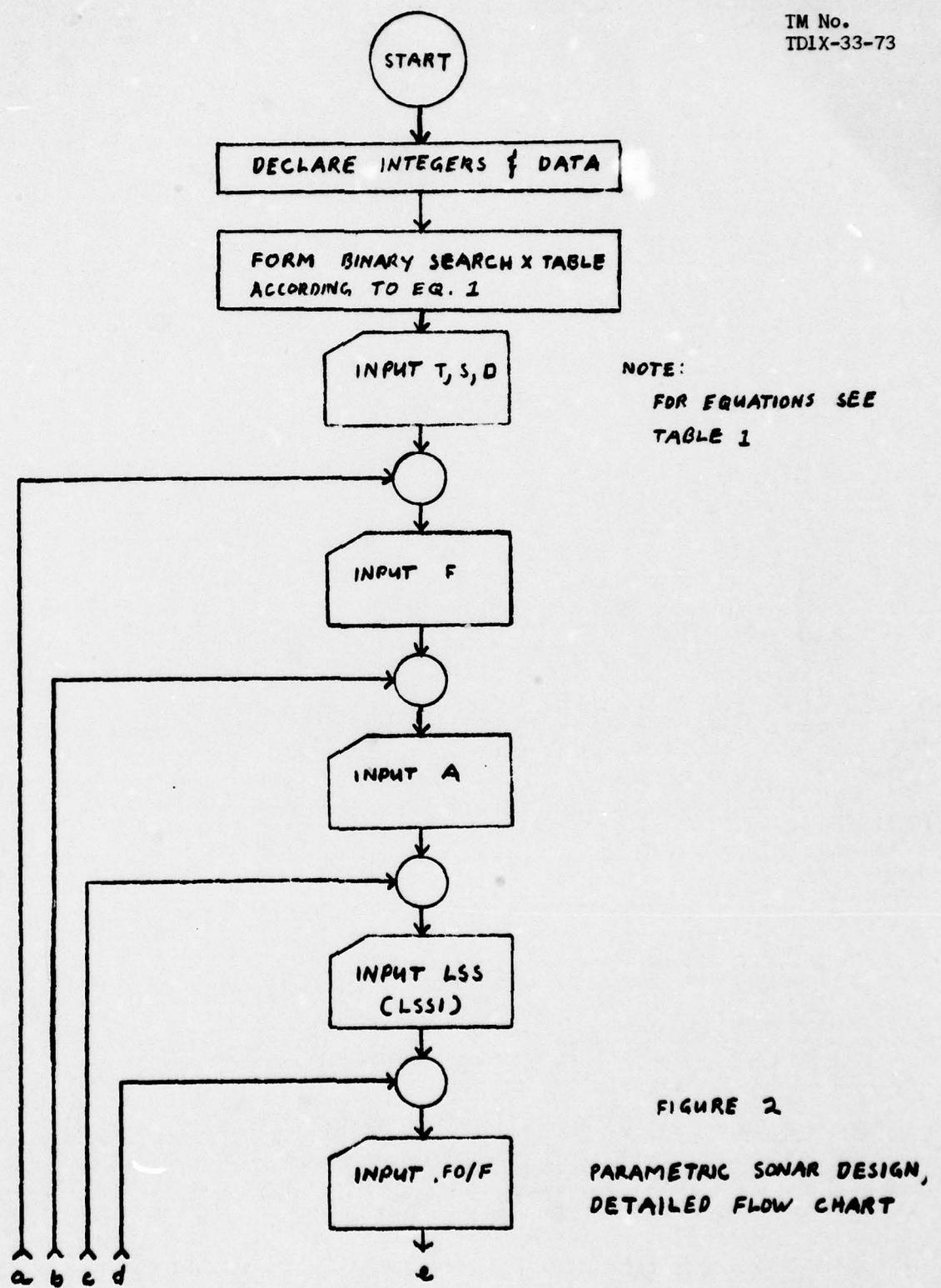


FIGURE 2

PARAMETRIC SONAR DESIGN,  
DETAILED FLOW CHART

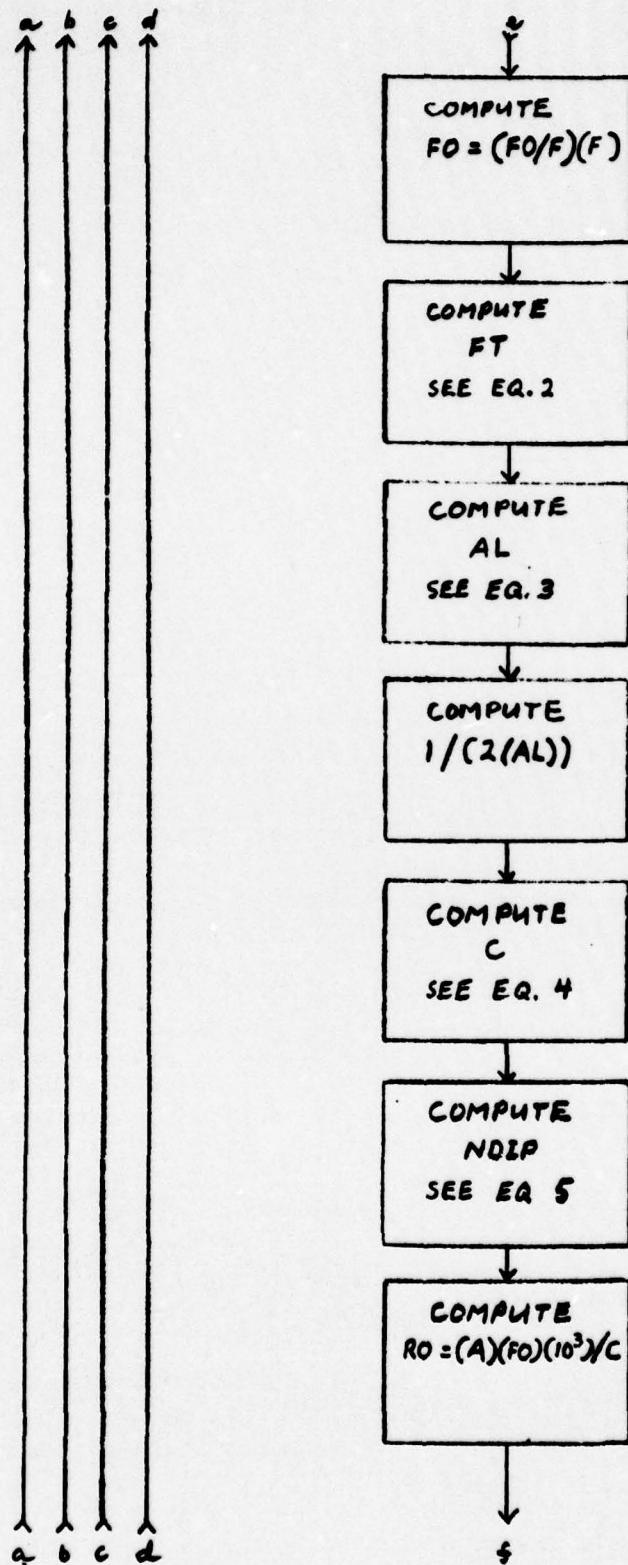


FIGURE 2 (CONT. 1)

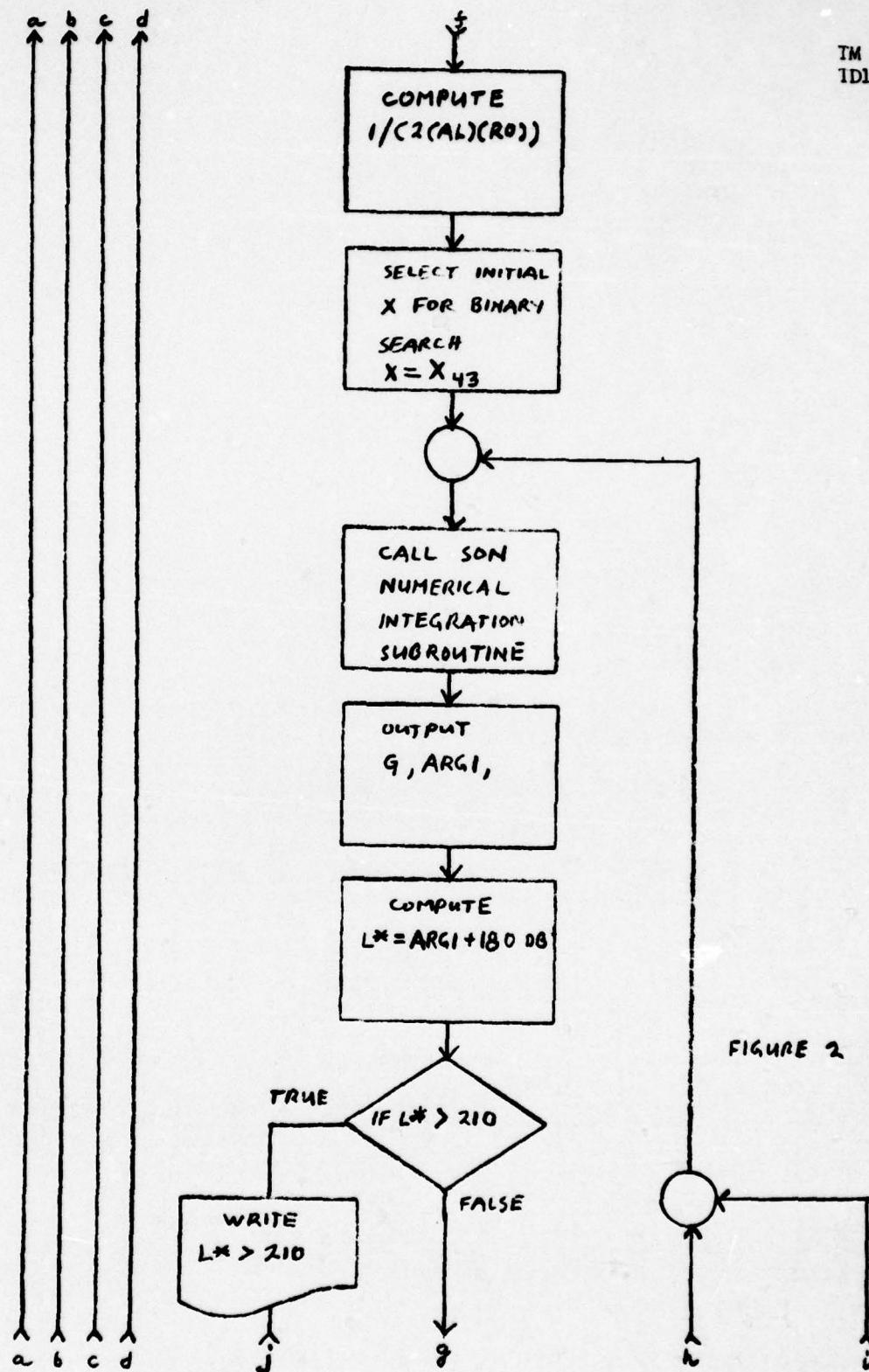


FIGURE 2 (CON'T 2)

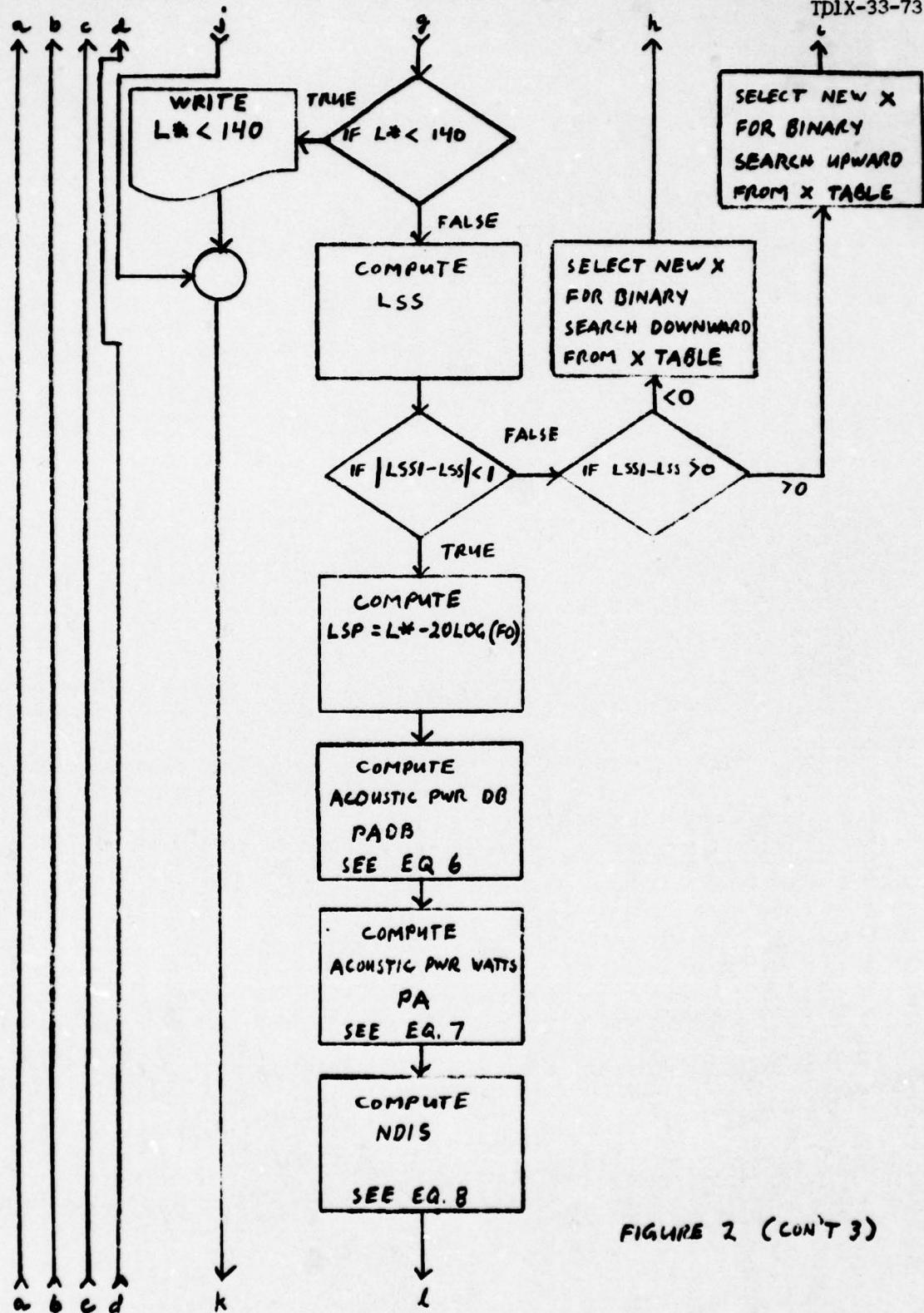


FIGURE 2 (CONT'D)

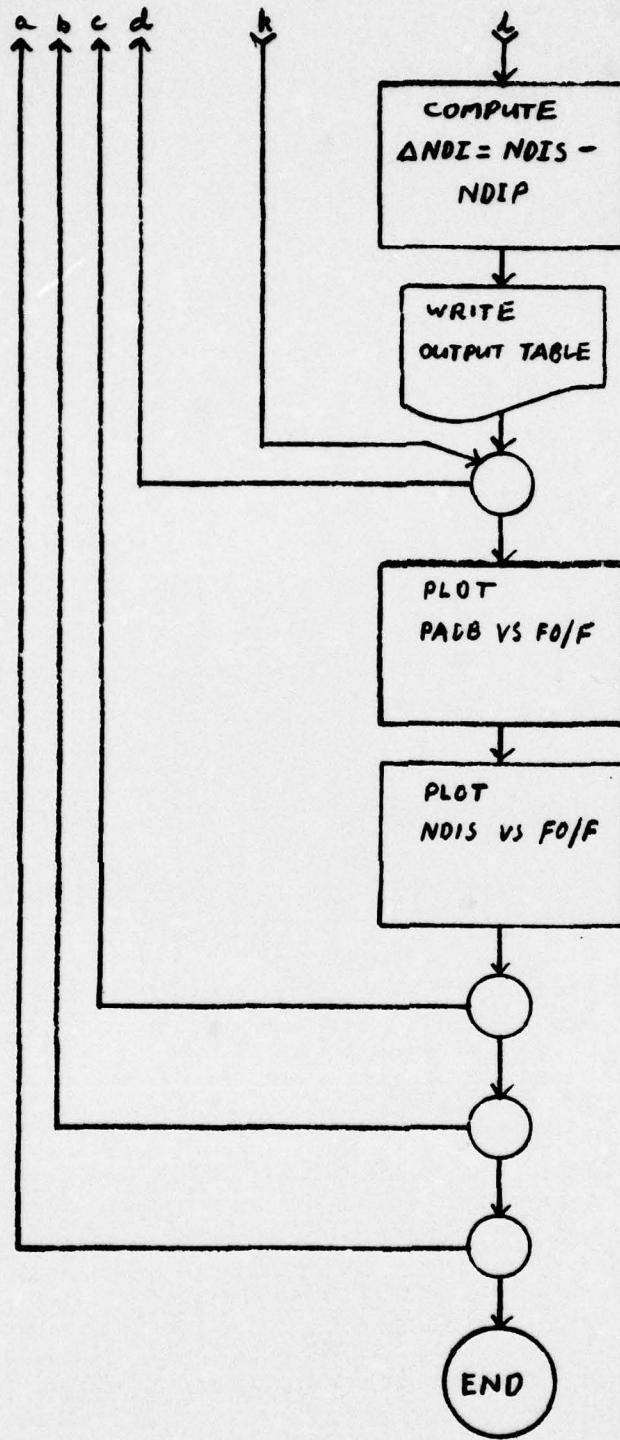


FIGURE 2 (CONT. 4)

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FIGURE 3  
SAMPLE EXAMPLE DATA FORMAT

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APPENDIX A  
PROGRAM COMPILATION

The program compilation shown here is complete with subroutines except for the plot subroutine. That particular one was on tape and was not compiled as was the material that was put in by means of a deck of cards.

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FOR SUBJU  
UNIVAC 1108 FORTRESS V LEVEL 2206 0026 (EXEC8 LEVEL E1201-0011)  
THIS COMPILED WAS DONE ON 14 JUN 73 AT 21:34:46

21139146..50

SUBROUTINE SUB ENTRY POINT 000067

STORAGE USED: CODE(1) 0001031 DATA(0) 0000201 BLANK COMMON(2) 0000000

COMMON BLOCKS:

0003 BLK 000010

EXTERNAL REFERENCES (BLOCK, NAME)

0004 USINH	
0005 DEXP	
0006 USQRT	
0007 NERK3S	

STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0003 D 000000 AHO	0003 D 000006 E	0003 D 000002 GKD0	0000 000012 INPS	0000 000000 T
0003 D 000008 X				

```
00101 1*      SUBROUTINE SUB(A,J,H,F)
C0102 2*      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C0103 3*      COMMON/BLK/AR0,GKD0,X,E
C0104 4*      TEAT+J*H
C0105 4*      F=USINH(T)
C0106 5*      TE1=0.00+((A*T)**2)/4.000
C0107 6*      IF (AR0.GT.0.000) E=DEXP(-F*AR0)
C0108 7*      F=F**2
C0110 7*      F=(1.000+F)/(1.000+F*GKD0**2)
C0111 8*      FEE=DSQRT(F1/T)
C0112 8*      RETURN
C0113 9*      END
C0114 10*     END
C0115 11*     END
C0116 12*     END
```

END OF COMPILATION: NO DIAGNOSTICS.

FOR NOM-NOM  
UNIVAC 1108 FORTRAN V LEVEL 2206 0026 (EXEC8 LEVEL E1201-0011)  
THIS COMPILED ON 14 JUN 73 AT 21:34:47

TM No.  
TDIX-33-73  
21134147. 40

SUBROUTINE RUM ENTRY POINT 000246

STORAGE USED: CORE(1) 0002751 DATA(0) 0000601 BLANK COMMON(2) 0000000

EXTERNAL REFERENCES (BLOCK, NAME)

0003	SUB
0004	NEAPJS
0005	NEAPYS
0006	NEARJS

STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0001	000071	1206	0001	000120	1306	0001	000033	4L	0000 D 000005 FN
0000	D	000009	H	0000	000031	INJPS	0000	I	000015 JU
0000	I	000002	K	0000	1	000014 L	0000	I	000011 H
								D	000007 SIG

```

10      SUBROUTINE ROM(A,B,W,EPS,IV,NMX)
C0101   1*      DIMENSION A(NMX,NMX)
C0102   2*      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C0103   3*      H=U-A
C0104   4*      K=0
C0105   4*      CALL SUB(A,0,H,F)
C0106   5*      FN=F
C0107   6*      CALL SUB(A,1,H,F)
C0110   7*      CALL SUB(A,1,H,F)
C0111   8*      K(1,1)=(F+FN)*H1/2.0D0
C0112   9*      K=K+1
C0113  10*      CALL SUB(A,J1,H,F)
C0114  11*      H1=H/2.000
C0115  12*      SIG=0.000
C0116  13*      K=K*(K-1)
C0117  14*      UU 1  J=1,M
C0122  15*      J1=2+J-1
C0123  16*      CALL SUB(A,J1,H,F)
C0124  17*      SIG=SIG+F
C0126  18*      K(K+1)=M(K,1)/2.0D0+H*SIG
C0127  19*      UU 2  L=L,K
C0132  20*      U=L-K+1-L
C0133  21*      IV=L+1
C0134  22*      2  ((IU,IV)=(4.0D0**((IV-1)*W(IU+1,IV-1)-W(IU,IV-1))/(4.0D0**((IV-1)-1.
C0134  23*      1D0)
C0136  24*      IF (ABS(W(IU,IV))-W(IU,IV-1)).LT.ABS(W(IU,IV)) .EPS) RETURN
C0140  25*      GO TO 4
C0141  26*      END

```

A-3      END OF COMPILATION!      NO DIAGNOSTICS.

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a. FOR SON, SUN  
UNIVAC 1108 FORTKAN V LEVEL 2206 0026 (EXEC0 LEVEL E1201-0011)  
THIS COMPILED AS DONE ON 14 JUN 73 AT 21:34:48

21134100.366

SUBROUTINE SUN ENTRY POINT 000134

STORAGE USED: CODE(1) 0001601 DATA(0) 0116641 BLANK COMMON(2) 0000000

COMMON BLOCKS:

0003 BLK 000010

EXTERNAL REFERENCES (BLOCK, NAME)

0001	ROM
0002	DLOG
0006	DATAN
0007	DLOG10
0010	NRH35

STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0001	000045	IL	0000 D 011612 A
0003	0 00006	E	0000 D 011610 EPS
0000	011650	INPS	0000 1 011624 IV

0003	D 0000000	ALN1	0003 D 0000000 ARO
0003	D 00002	FAC	0003 D 0000002 GRDKO
0003	D 00004	W	0003 D 0000004 X

00101 1\* SUBROUTINE SON (RARG,RKUKO,ARG,ANS,AIN,NMX)  
00102 2\* IMPLICIT DOUBLE PRECISION (A-H,O-Z)  
00103 COMMON/BLK/ARG,GDKKO,X,E  
00104 DIMENSION A(150,50),  
00105 EPSS=5E-05  
00106 AE=0.0  
00107 BE=0.0  
00108 CDO=1.00  
00109 AKU=0.000  
00110 C0111 9\* IF (RARG.GT.ARO) ARO=1.000/RARG  
00111 10\* GKKO=1.000/RKUKO  
00112 C0112 11\* GKKO=GGKKO\*2  
00113 12\* \*DIAGNOSTIC\* THE TEST FOR EQUALITY BETWEEN NON-INTEGERS MAY NOT BE MEANINGFUL.  
00114 13\* 00117 1.3\* IF (RARG.EQ.0.000) GO TO 1  
00118 14\* AL1=DLOG (RKUKO)  
00119 15\* BE=DLOG ((R4\_000+ALN1)\*RARG)  
00120 16\* 1 FAC=GRKKO\*(X/2.000)  
00121 17\* CALL HUM(A,B,W,EPSS,IV,50)  
00122 18\* AIN=1.1V  
00123 19\* \*DIAGNOSTIC\* THE TEST FOR EQUALITY BETWEEN NON-INTEGERS MAY NOT BE MEANINGFUL.  
00124 20\* 00126 21\* 1.000\*X)/X  
00127 22\* AIN=FC\*AIN  
00128 23\* ANG=20.000\*DL0610(X)  
00129 24\* ANG=20.000\*DL0610(AIN)

1.000\*X)/X  
AIN=FC\*AIN  
ANG=20.000\*DL0610(X)  
ANG=20.000\*DL0610(AIN)

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00133 24\* RETURN  
00134 25\* ENQ

END OF COMPLAINTS 2 DIAGNOSTICS.

21134199.464

FOR SONAKI/SUNAR  
UNIVAC 1108 FORTRAN V LEVEL 2206 0026 (EXECB LEVEL E1201-0011)  
THIS COMPILED WAS DONE ON 14 JUN 73 AT 21134149

MAIN PROGRAM

STORAGE USED: CODE(11) 0010121 DATA(0) 0045361 BLANK COMMON(12) 0000000

COMMON BLOCKS:

0003 BLK 000000

NSTOPS

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TM No.  
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```

62      ALMx)    DOUBLE PRECISION AHO,GKDKO,X,E,AIN,XO,ARG,ANS,RARO1,RFDF01
63      7*      DOUBLE PRECISION XX(1LMX)
64      8*      COMMUN/BLK,ARO,GDKO,X,E
65      9*      ICARD=3
66      10*     ICARD=3
67      11*     IPRINT=4
68      12*     P1=3,14159
69      13*     C
70      14*     CARU   COLUMNS   FORMAT   ARGUMENT
71      15*     C       1       1-5      15      KN- NO. OF F VALUES
72      16*     C       1       6-10     15      KN1- NO. OF A VALUES
73      17*     C       1       11-15    15      KN2- NO. OF LSS VALUES
74      18*     C       1       16-20    15      KN3- NO. OF FO/F VALUES +1
75      19*     C       2       1-10     15      T
76      20*     C       2       1-10     15      F10.4
77      21*     C       2       11-20    15      F10.4
78      22*     C       2       21-30    15      F10.4
79      23*     C       2       21-30    15      D
80      24*     C       2       21-30    15      IN THE FOLLOWING CARDS, IF MORE THAN ONE VALUE OF THE VARIABLES
81      25*     C       2       21-30    15      IS DESIGNED (BASED ON CARD NO.1) THEN RELATED CARDS (ALL F'S) MUST
82      26*     C       3       1-10     15      BE GROUPED TOGETHER
83      27*     C       4       1-10     15      F
84      28*     C       5       1-10     15      A
85      29*     C       5       1-10     15      LSS
86      30*     C       6       1-10     15      FO/F
87      31*     C       X0=.909090910E-2
88      32*     C       DO B I=1,8b
89      33*     C       X(I)=1.19A0
90      34*     C       A=X(I)
91      35*     C       HEAD(ICARD,101) KN,KN1,KN2,KN3
92      36*     C       101 FORMAT(15)
93      37*     C       N$KN
94      38*     C       N1=KN1
95      39*     C       N2=KN2
96      40*     C       N3=KN3
97      41*     C       N4=N3+A
98      42*     C       HFU(F14)=0.0
99      43*     C       PALB(1)=0.0
100     44*     C       HDIS(1)=0.0
101     45*     C       IF PORE IS IN EXCESS OF 100KW CHANGE SCALE OF PADB PLOT
102     46*     C
103     47*     C
104     48*     C       PAUD(N4)=50.
105     49*     C       HJS(N4)=50.
106     50*     C       H$U(F14)=0.0
107     51*     C       HEAD(ICARD,102) T,S,D
108     52*     C       102 FORMAT(3F10.4)
109     53*     C       HEAD(ICARD,100) (F(1A),IA=1,N)
110     54*     C       HEAD(ICARD,100) (A(1B),IBE=1,N1)
111     55*     C       HEAD(ICARD,100) (LSS1(IC1),IC=1,N2)
112     56*     C       HEAD(ICARD,100) (RFDF01(ID),ID=2,N3)
113     57*     C       C=1449.2+623*T-.0546*(T*2)+1.391*(S-35).1+.017 *0
114     58*     C       DO 1 1E1,KN
115     59*     C       1E1,KN1
116     60*     C       DO 3 J=1,KN2
117     61*     C       WRITE(IPRINT,107)
118     62*     C       WRITE(IPRINT,103)
119     63*     C       WRITE(IPRINT,104)

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A-7

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640      WRITE(IPR1,T104) T,0,S,C,A(11)
650      WRITE(IPR1,T105)
660      DO Q J=2,NN3
670      F0(JJ)=RFUFO(JJ)*F(1)
680      E=(10.*JJ)*F0(JJ)
690      F1=21.*9*10.*a*(6.-1520./((1+273.)))
700      ALPHA(JJ)=(1./8.68)*(1.-(.00000332*Q))*((1./914.*S1*0186*1*(SSF1*(E
710      10.(JJ)**2.)/(F1**2.))+(.0268*F0(JJ)**2./F1)**2.))
720      2*(2.)/1.+F0(JJ)**2.))
730      NU1(JJ)=10.*AL0610((N.*P1*A(11)*E**2.)/C
740      R0(JJ)=(A(L1)*F0(JJ)*10.***3.)/C
750      RA0(JJ)=1.0/(2.*ALPHA(JJ)*R0(JJ))
760      ADUM(JJ)=1.0/(2.*ALPHA(JJ))
770      NLX=16
780      IMIN=1
790      IMAX=NLX
800      IM1=NLX/2
810      IM2=NLX/2
820      IOP=0
830      20  LU 5  LIX=1.91
840      X=A(I,IMD)
850      RAN0=RAKO(JJ)
860      RFUFO=RFUFO(JJ)
870      CALL SUN(RAR0,RFUFO1,ARG,ANS,AIN,50)
880      ANG1(JJ)=ANG
890      ANS1(JJ)=ANS
900      ANG(JJ)=ANG1(JJ)+180.
910      IF (ARG1(JJ).NE.210.) GO TO 210
920      IF (ANG1(JJ).LT.140.) GO TO 220
930      LSS(JJ)=ANG1(JJ)-20.*AL0610(F0(JJ))+ANS1(JJ)
940      IF (LIS(LSS1(JJ))-LSS(JJ)).LT.1.) GO TO 200
950      IF (IOP1.NE.0) GO TO 15
960      IOP=1
970      IF (LSS1(JJ)-LSS(JJ).LT.12.12.13
980      12  ICONST=-1
990      1DUM1=IMIN
1000      1DUM1=IMID
1010      GO TO 14
1020      13  ICONST=1
1030      1DUM1=IMAX
1040      ICONST=-1
1050      14  1DUM2=1DUM1+1DUM2+ICONST1/2
1060      1DUM2=1DUM2
1070      GO TO 5
1080      15  ICONST=1
1090      16  ICONST=-1
1100      1DUM1=1DUM2
1110      ISAVE=1ID
1120      1DUM2=1DUM2
1130      1DUM2=1DUM1+1DUM2+ICONST1/2
1140      GO TO 5
1150      17  ICONST=-1
1160      1DUM2=1SAVE
1170      1DUM1=1DUM2
1180      1DUM2=1DUM1+1DUM2+ICONST1/2
1190      1CONTINUE
1200      180  LS(JJ)=ARG1(JJ)-20.*AL0610(F0(JJ))
1210      PAUL(JJ)=EXP(JJ)-70.*RDIP(JJ)
1220      DMAX=JEPAD(JJ)
1230

```

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1220
00360          H(J,J)=10.0,ADUM
00361          NDIS(J,J)=(NDIP(J,J)+3.)-10.*AL0610(1.0+INFO(1,JJ))*(2.*PI+ALPHA(JJ))*R
00362          123*
00363          124*
00364          125*
00365          126*
00366          127*
00367          128*
00368          129*
00369          130*
00370          131*
00371          132*
00372          133*
00373          134*
00374          135*
00410          136*
00411          137*
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00414          140*
00433          141*
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00433          144*
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00436          146*
00437          147*
00441          148*
00443          149*
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00446          167*
00446          168*
00446          169*
00447          170*
00447          171*
00450          172*
00450          173*
00450          174*
00451          175*
00451          176*
00452          177*
00453          178*
00453          179*
          NDIS(J,J)=NDIS(J,J)-NDIP(J,J)
          DELN(J,J)=NDIS(J,J)-NDIP(J,J)
          KHTL(IPRINT,106) F(11)*PAUB(JJJ),RFDF0(JJJ),F0(JJJ),ALPHA(JJJ),ADUM(JJJ),RO(JJJ),KARO(JJJ),NDIP(JJJ),LSS(JJJ),LSP(JJJ),ANG1(JJJ),ANS1(JJJ),PA(JJJ),NUIS(JJJ),DELNDI(JJJ)
          60 TO 4
          210 LSP(JJJ)=0.0
          PAUB(JJJ)=0.0
          NDIS(JJJ)=0.0
          NDIS(JJJ)=0.0
          KHTL(IPRINT,112) F(11)*PAUB(JJJ),RFDF0(JJJ),F0(JJJ),ALPHA(JJJ),ADUM(JJJ),LJ,RO(JJJ),KARO(JJJ),NDIP(JJJ),LSS(JJJ),LSP(JJJ),ANG1(JJJ),ANS1(JJJ)
          60 TO 4
          220 LSP(JJJ)=0.0
          PAUB(JJJ)=0.0
          NDIS(JJJ)=0.0
          NDIS(JJJ)=0.0
          WRITE(IPRINT,113) F(11)*PAUB(JJJ),RFDF0(JJJ),F0(JJJ),ALPHA(JJJ),ADUM(JJJ),LJ,RO(JJJ),KARO(JJJ),NDIP(JJJ),LSS(JJJ),LSP(JJJ),ANG1(JJJ),ANS1(JJJ)
          4 CONTINUE
          C   THE PLOT ROUTINES ARE ON TAPE U183
          C
          CALL PLOTA(RDFD0,PADB,PY,N4,1H+,1,I'PADB VS FO/F',2,IPRINT)
          CALL PLOTA(RDFD0,NUIS,PY,N4,1H+,1,I'NOIS VS FO/F',2,IPRINT)
          3 CONTINUE
          2 CONTINUE
          1 CONTINUE
          100 FORMAT(F10.5)
          103 FORMAT(50X,'TE WATER TEMPERATURE (DEGREES C)')
          1./50X,'D= PROJECTOR DEPTH (METERS)',/
          3./50X,'S= SALINITY (PPT)',/
          4./50X,'F= SECONDARY FREQUENCY (KHZ)',/
          5./50X,'A= PROJECTION AREA (SQ. METERS)',/
          6./50X,'FO= PRIMARY FREQUENCY (KHZ)',/
          7./50X,'LSS= SECONDARY SOURCE LEVEL (DB/MICROBAR-METER)',/
          8./50X,'LSP= PRIMARY SOURCE LEVEL (DB/MICROBAR-METER)',/
          9./50X,'L2A= REACTION LIMIT (METERS)',/
          11/50X,'RU= RAYLEIGH DISTANCE (METERS)',/
          2/50X,'NDI1= DIRECTIVITY INDEX-PRIMARY (DB)',/
          3/50X,'NDI2= DIRECTIVITY INDEX (DB)',/
          4/50X,'LSP= PRIMARY SOURCE LEVEL (DB/MICROBAR-METER)',/
          5/50X,'L+ SCALED SOURCE LEVEL (DB/MICROBAR-METER-KHZ)',/
          6//50X,'G2= PARAMETER GAIN (DB)',/
          7//50X,'P4= ACOUSTIC POWER PER TONE (MILLS)',/
          8//50X,'AND1= DIRECTIVITY GAIN (DB)',/
          9//50X,'AND2= SECONDARY DIRECTIVITY INDEX (DB)',/
          1//50X,'PAUB= ACUSTIC POWER (DB/WATT) PER EACH PRIMARY TONE')
          104 FO,HAII(/5A,A='F5.0,./5X,U=','FB.1,./5X,S=','F4.0,./5X,C=','
          1FO.0,./5X,A='F9.4)
          105 FO,HAII(5X,'FO,'5X,'FO,'8X,'PAUB,'3X,'FO,'5X,'1/2AL','5X,'R
          106 FO,HAII(5X,'1/2ALR,'1X,'NDIP,'3X,'LSS,'4X,'LSP,'4X,'L+,,'5X,'G,'5X,'PA(
          2,ATTS),'1X,'NOIS','2X,'AND1')
          106 FO,HAII(F9.5,3X,F5.1,1X,F7.2,1X,F8.3,1X,F9.6,1X,F7.0,1X,F7.0,1X,F8,
          11/1X,Fb.1,1X,F6.1,1X,F6.1,1X,F6.1,1X,F5.1,1X,F5.1,2X,F5.1)
          107 FO,HAII(49X,'PARAMETRIC SONAR DESIGN AND ANALYSIS'),/
          112 FO,HAII(F9.2,3X,F5.1,1X,F7.2,1X,F8.3,X,F9.6,X,F7.0,1X,F7.0,1X,F8,
          11/1X,Fb.1,1X,F6.1,1X,F6.1,1X,F5.1,1X,F5.1,2X,F5.1)

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00034	160*	113 FORMAT(1F9.3,1X,F5.1,1X,F7.2,1X,F8.3,1X,F9.6,1X,F7.0,1X,F7.0,1X,F8.
00034	181*	11-1X,F5.1,1X,F6.1,1X,F6.4,1X,F5.1,1X,F5.1,10X,'L# < 140.')
00035	162*	114 FORMAT(1ML)
00036	163*	STOP
00037	164*	END

END OF COMPILED: NO DIAGNOSTICS.

APPENDIX B  
SAMPLE EXAMPLE READOUT

The sample example tables and plots are shown here. These are as they appear on line out of the high speed printer associated with the computer.

TM No.  
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PARAMETRIC SONAR DESIGN AND ANALYSIS  
T= WATER TEMPERATURE (DEGREES C)

U= PROJECTOR DEPTH (METERS)

S= SALINITY (PPT)

F<sub>2</sub>= SECONDARY FREQUENCY (KHZ)

A= PROJECTOR AREA (SQ. METERS)

F<sub>0</sub>/F<sub>2</sub>= DOWNSHIFT RATIO

F<sub>0</sub>= PRIMARY FREQUENCY (KHZ)

AL= ABSORPTION CONSTANT (NEPERS/METER)

L/2AL= REACTION LIMIT (METERS)

R<sub>0</sub>= RAYLEIGH DISTANCE (METERS)

NDP= DIRECTIVITY INDEX-PRIMARY (DB)

L<sub>SS</sub>= SECONDARY SOURCE LEVEL (DB/MICROBAR-METER)

L<sub>SP</sub>= PRIMARY SOURCE LEVEL (DB/MICROBAR-METER)

L<sub>0</sub>= SCALED SOURCE LEVEL (DB/MICROBAR-METER-KHZ)

G= PARAMETER GAIN (DB)

P= ACOUSTIC POWER PER TONE (WATTS)

AND= DIRECTIVITY GAIN (DB)

NDIS= SECONDARY DIRECTIVITY INDEX (DB)

PABD= ACOUSTIC POWER (DB/WATT) PER EACH PRIMARY TONE

T3 7.

D3 .0

S2 35.

C3 1479.

AS	.1969	F <sub>0</sub>	F <sub>0</sub> /F	AL	1/2AL	R0	1/2ALRU	MDIP	LSS	LSP	L <sub>p</sub>	PA (WATTS)	NOTS.	AND?
3.000	30.7	5.00	15.000	.000241	2079.	20	1043.5	24.0	69.4	125.6	149.1	136.2	1185.2	26.4
3.000	29.5	7.50	22.500	.000506	989.	30	330.5	27.6	91.0	127.7	151.9	136.9	689.0	26.4
3.000	27.8	10.00	30.000	.000946	591.	40	140.3	30.1	89.9	126.7	150.2	135.9	603.0	1.3
3.000	27.4	12.50	37.500	.001427	404.	50	61.1	32.0	89.7	130.0	161.5	140.3	522.4	30.3
3.000	27.4	15.00	45.000	.001657	302.	60	50.5	33.6	90.2	131.0	164.8	141.5	547.3	30.0
3.000	26.2	20.00	60.000	.002510	199.	60	25.0	36.1	90.5	135.4	170.6	144.6	657.6	27.1
3.000	31.4	30.00	90.000	.004021	124.	120	10.4	39.6	89.6	141.5	180.6	152.3	1279.5	26.4
3.000	36.0	40.00	120.000	.005166	90.	160	6.1	42.1	89.2	148.9	190.5	159.4	3987.5	23.2
3.000	36.0	50.00	150.000	.006209	82.	200	4.1	44.0	89.4	153.0	197.1	144.2	7504.9	21.0
3.000	42.0	70.00	210.000	.007653	65.	260	2.3	47.0	89.3	159.0	206.2	170.5	15902.7	16.1
3.000	42.0	100.00	300.000	.009269	50.	400	1.3	50.1	83.0	210.4	216.9	176.9	Le > 210.	

TM No.  
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PAD 1 VS. FO/F

50.0000 -

45.0000 -

40.0000 -

35.0000 -

30.0000 -

25.0000 -

20.0000 -

15.0000 -

10.0000 -

5.0000 -

1.0000 -

.0000 -

XSCALES .10000000+01  
YSCALES .10000000+01

TM No.  
TDIX-33-73

NDIS-4S.F0/F

50.000

45.000

10000

200

1

4

— 1 —

一一一

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1

XSCALAR YSCALAR



PAGE 60/F

TM No.  
TDIX-33-73

50.000

45,000

2

104

10

1

100

B-7

NOIS VS FU/F

TM No.  
TDIX-33-73

50.0000

45.0000

40.0000

35.0000

30.0000

25.0000

20.0000

15.0000

10.0000

5.0000

.0000

X .0000 10.0000 20.0000 30.0000 40.0000 50.0000 60.0000 70.0000 80.0000 90.0000 100.0000  
XSCALE=.10000000+01  
YSCALE=.10000000+01

TM No.  
TDIX-33-73

Ts 7.

Us .0

Ss 35.

Cs 1479.

A# 7654

F	P4Ua	Fu/F	FO	AL	1/2AL	HO	1/2ALRU	NUIP	LSS	LSP	L*	G	P(MATT)	NDIS	ANOL
3.000	26.6	5.00	15.000	.000241	2079.	6.	260.9	30.1	90.2	127.2	150.8	-37.0	433.9	32.2	2.1
3.000	25.4	7.50	22.500	.000506	988.	12.	82.7	33.6	90.7	129.5	156.6	-38.8	325.5	34.1	.5
3.000	24.3	10.00	30.000	.000896	591.	16.	37.1	36.1	89.9	131.2	160.7	-41.2	267.1	34.4	-1.7
3.000	24.6	12.50	37.500	.001237	404.	20.	20.3	38.0	90.1	133.4	164.8	-43.3	283.8	33.9	-4.1
3.000	25.3	15.00	45.000	.001657	302.	24.	12.6	39.6	90.7	135.9	169.0	-45.2	355.0	33.1	-6.5
3.000	27.1	20.00	60.000	.002510	199.	32.	6.3	42.1	90.2	140.0	175.6	-49.9	516.1	31.5	-10.6
3.000	30.6	30.00	90.000	.004021	124.	48.	2.6	45.6	89.6	147.3	164.4	-57.7	1215.0	28.6	-17.0
3.000	34.1	40.00	120.000	.005106	90.	64.	1.5	48.1	90.3	153.1	194.6	-62.8	2586.3	26.4	-21.8
3.000	35.2	50.00	150.000	.006109	82.	80.	1.0	50.1	89.5	156.1	199.6	-66.6	3324.7	25.1	-25.0
3.000	36.5	70.00	210.000	.007053	65.	112.	.6	53.0	95.4	162.3	208.7	-71.8	7044.9	22.4	
3.000	36.5	100.00	300.000	.009909	50.	159.	.3	56.1	81.0	.0	210.4	-78.8	L* > 210.		



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45.0000 -

40.0000 -

35.0000 -

30.0000 -

25.0000 -

20.0000 -

15.0000 -

10.0000 -

5.0000 -

B-11

.0000 .0000 10.0000 20.0000 30.0000 40.0000 50.0000 60.0000 70.0000 80.0000 90.0000 100.0000  
X.....  
SCALE 1.....  
10000000+01.....  
10000000+01.....  
YSCALES.....  
YSCALES.....

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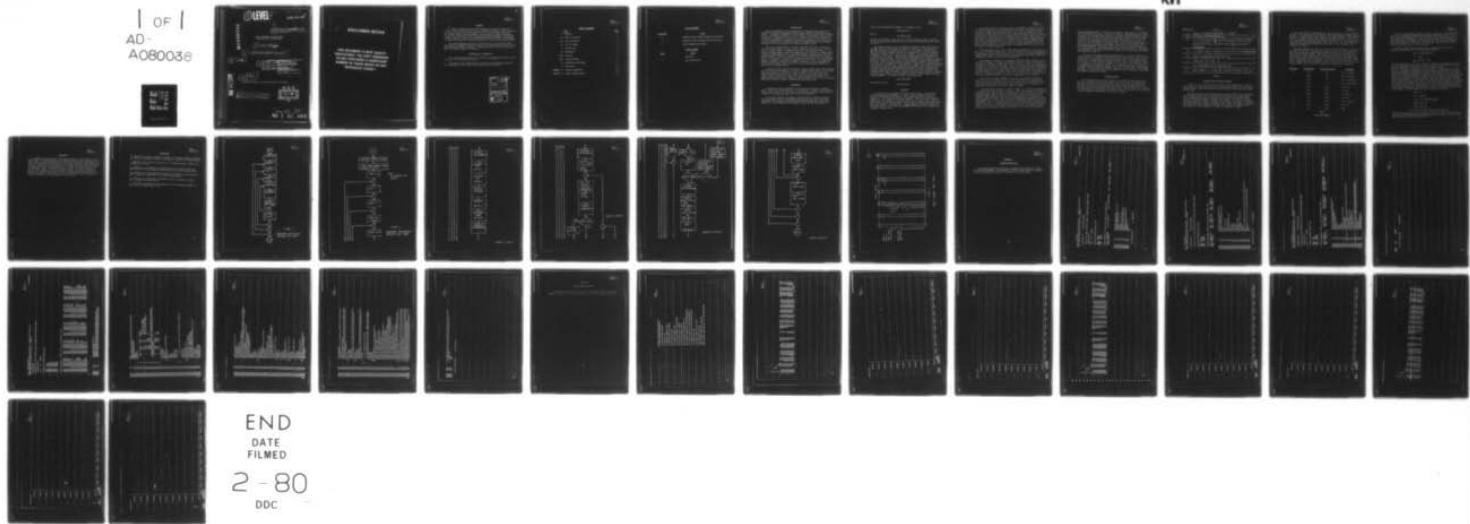
NAVAL UNDERWATER SYSTEMS CENTER NEWPORT RI  
COMPUTER AIDED PARAMETRIC SONAR DESIGN. (U)  
MAY 73 E C GANNON, R P PINGREE  
NUSC-TM-TDIX-33-73

F/G 17/1

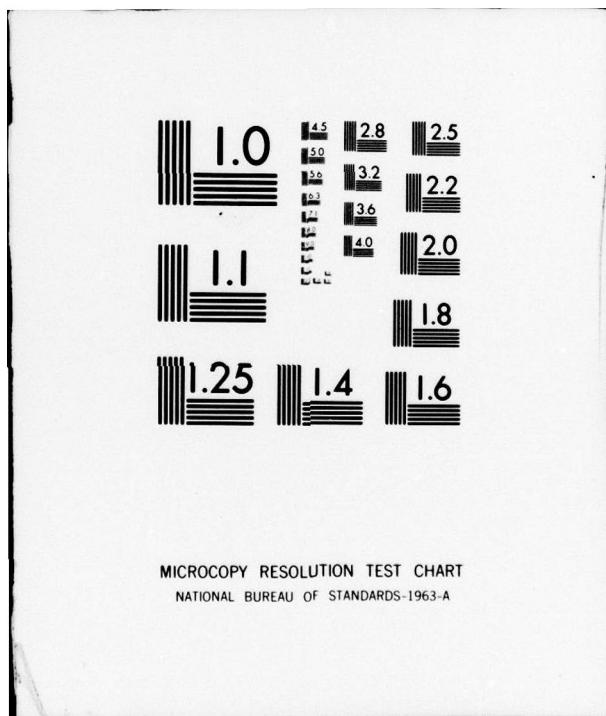
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NAVAL UNDERWATER SYSTEMS CENTER  
Newport, Rhode Island 02840

⑨ Technical Memorandum

⑥ COMPUTER AIDED PARAMETRIC SONAR DESIGN

⑪ 23 May 73

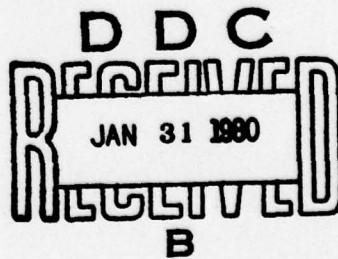
Prepared by, Edmund C. Danner  
Edmund C. Gannon,  
Parametric Sonar Group  
Robert P. Pingree  
A. J. Van Winkle  
R. P. Pingree  
Digital Computing Division

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### ABSTRACT

A computer program was written that enables the design of parametric sonars. This program accepts as inputs temperature, salinity, depth, estimates of projector area, desired secondary source level and secondary frequency. The program computes various parametric sonar quantities among them primary source level, directivity index and primary operating frequency. The program actually generates a matrix of possible design values that permit the designer to choose those which best suit his needs based on other system considerations.

The design program is written in Fortran V for use on the Univac 1108. The program is completely general and any of the input parameters can be varied while holding the others constant. A discussion on how to use the program as well as a sample example is included.

### ADMINISTRATIVE INFORMATION

This memorandum was prepared under Project No. A-614-19, Principal Investigator, Dr. A. J. Van Woerkum, Code TC.

The authors of this memorandum are located at the New London Laboratory, Naval Underwater Systems Center, New London, Connecticut 06320.

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## INTRODUCTION

From the viewpoint of the individual who is faced with the design of a parametric sonar, the calculations involved seem repetitive and in some cases endless. The Mellen and Moffett<sup>1</sup> curves together with the appropriate equations given in the reference contain all of the necessary information. However, the information is presented in such a way as to make it easy to work through the curves and calculations to analyze the parametric operation of existing projectors and systems but it is difficult and not straightforward to work backward through the curves and equations to design a projector system.

There is a solution which is offered by Moffett<sup>2</sup> that uses a "load line" type of technique similar to that used in vacuum tube circuit design. This is good for a small number of possible designs of a given parametric sonar. The method requires, however, repetitive computations to arrive at the dimensionless parameters  $1/(2)(AL)(RO)$  for each possible parametric stepdown ratio (the ratio of the parametric difference frequency to the mean projector driving frequency  $FO/F$ ). The term  $(AL)$  is absorption in nepers per meter while  $RO$  is the Rayleigh distance. Appendix B contains a complete glossary of terms. The "load line" method is presently limited by the number of families of curves available for the different stepdown ratios and the accuracy of interpolating between the given curves of a given family.

A means, therefore, was devised where the whole design process was automated using the Univac 1108 computer. In essence, computer aided design. The solution allows the designer to work from a known secondary source level (LSS) and a known secondary frequency (F) for a range of values of projector size (A), primary source level per tone (LSP) and a given stepdown ratio (FO/F). The computer program will build a matrix of possible designs that can then be compared with other factors to achieve a workable and realistic design.

## BACKGROUND

In parametric sonar calculations, two distinct and different problems arise. One is that of the analysis of existing sonar to predict their parametric operating characteristics. The other is the design of parametric sonars having a given set or range of output source levels and frequencies.

In the first problem, one usually knows the primary operating frequency ( $FO$ ), the primary source level (LSP), and the projector area (A). From these one obtains the secondary source level (LSS) and secondary directivity index (NDIS) for a given downshift ratio ( $FO/F$ ) by using the Mellen and Moffett

curves and the appropriate formulae. In summary, we know

FO, LSP and A.

We find

LSS, FO/F, NDIS.

The Mellen and Moffett curves and the associate equations readily lend themselves to solving this problem because of the way the equations and the curves are set up.

The second problem is one of designing a parametric sonar starting from "scratch" where one only knows the desired, or the range of desired, LSS, F, and NDIS and wants to find FO, LSP and A. At first glance one would say, "Why not just work backwards through the equations with the aid of the Mellen and Moffett curves?" Alas, life is not so simple. The equations depend on a knowledge of FO, and A. In other words, something must be known about the projector before starting. Unfortunately, determining FO, A, and LSP is the goal of the design process. This is just the opposite of the analysis previously discussed. There is a method that has been proposed by Moffett that utilizes the "load line" technique previously mentioned. This method is excellent when an exact FO and A are sought for a given LSS, F, and NDIS. The method becomes time consuming and requires tedious repetitive calculations when a range of values is sought and when one needs numerous possibilities in order to examine and choose an optimum solution based on factors other than just parametric sonar considerations. What is needed is a method of constructing a matrix of possible parametric sonar designs for the designer to weigh in consort with associated system parameters. In summary for this situation we know

LSS, FO/F, NDIS

and we want to find

FO, LSP and A.

#### SOLUTION

The solution to the problem is computer aided design. A program was written that allows the designer to vary F, A, LSS, and FO/F in order to construct the desired design matrix. The program compilation is given in Appendix A. This program is versatile enough so that three other parameters temperature (T), salinity (S) and depth (D) can be varied in coarse steps and their effects on the design studied. The results are tabulated and two on-line plots are possible. The results of a sample example are shown in Appendix B. The on-line plots can be of any two variables and each plot can be altered by changing a computer card.

At present, one plot is acoustic power in dB (PADB) vs. FO/F for a given LSS with the parameters T, S, D, F and A held constant. Then either LSS, F, or A can be changed and another plot made. Thus, one can examine the range of possible designs that are within the desired power budget and select a reasonable one. The second plot is secondary directivity index (NDIS) vs FO/F for the same given conditions as in the previous plot. From this the designer can select the necessary quantities for a desired range of NDIS. Normally, many plots will be produced resulting in families of LSS curves with NDIS and PADB plotted against FO/F with T, S, D, constant for many combinations of F and A. Once a set of parameters is decided upon, the appropriate exact constants can be obtained from the tabulation.

One thing that has been done to aid in plot comparisons is to force the plots to a convenient common scale. This was done by the use of two dummy points on each plot. This was necessary because the routine as originally compiled by Gordon<sup>3</sup> automatically scaled the axis for the plotting range. For the desired comparisons of plots, such scaling is undesirable.

The program is outlined in a simplified flow chart shown in Figure 1. It operates as follows: The inner loop computes parametric sonar design constants for each of a sequence of FO/F values. This is done for each of a sequence of LSS values in the input data (LSS1). Next, the two inner loops are repeated for a sequence of values for A and finally these three innermost loops are repeated for each value of F in the input data. These four loops generate a matrix of possible designs for the ranges of FO/F, LSS, A, and F chosen. Each matrix is built up for constant values of T, S, and D. The values for T, S, and D can be altered by changing them when the data is programmed into the computer.

The plots as presently compiled plot after each sequence of FO/F for a given LSS. Thus, a family of curves of different LSS values is generated. These are for each combination of T, S, D, F, and A and are plotted with FO/F as the horizontal axis on each plot. The vertical axis on plot number 1 is PADB while the vertical axis on plot number 2 is NDIS.

A more detailed flow chart is shown in Figure 2. It shows an expansion of the computational block diagram of Figure 1. Thus, the location of the various calculations are shown along with the appropriate tests required to keep the program bounded. Once the data is entered, the calculations leading to the quantity  $1/(2)(AL)(RO)$  are made where the attenuation loss is (AL) and the Rayleigh distance is (RO). This quantity  $1/(2)(AL)(RO)$  together with the FO/F and a quantity X is entered into a numerical integration subroutine devised by Goldstein<sup>4</sup>. The X is a parameter that ties the integration to a scaled source level ( $L^*$ ) which is a normalized parametric quantity in the Mellen and Moffett theory. The output of the numerical integration enters into several simple computations, the results of which are tested to see if they fall within the

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proper programmed bounds. If the tests are failed, a new value of X is chosen and the integration routine is redone and retested. Depending on how the tests are passed, the program either proceeds to calculate further parametric sonar quantities for the given solution of the numerical integration or the program recognizes that the numerical integration has searched as far as it can. In any event, the program will proceed to readout the results in a table then recycle to the next FO/F in the innermost loop. Once the desired LSS values have been completely investigated, the computer constructs the two on-line plots previously mentioned. The program then recycles until all possible values of F, A, LSS and FO/F have been investigated and all plots completed. The program then terminates. The detailed flow chart (Figure 2) references equations which are tabulated in Table I.

In essence, the program takes some known values for a given condition and hunts, by means of a numerical integration routine and specific tests, for other needed values to completely describe a parametric sonar. Since usually there is a range of desired values, the program builds a matrix of possible solutions. The accuracy of these solutions depends on the accuracy of the parameter X used in the numerical integration. Presently, the solution calculates an LSS which is compared with the input LSS (LSS1). The calculated value has a tolerance of  $\pm 0.82$  dB. The resultant LSP, parametric gain (G), acoustic power (PA and PADB), and primary frequency directivity index (NDIP) all have a tolerance of  $\pm 0.41$  dB. The NDIS has a  $\pm 0.82$  dB tolerance.

#### PROGRAM OPTIONS

The design program has certain options as a result of the general form in which it is written. The program contains four nested loops any of which can be varied or held constant by appropriate input data on the input data cards. The plots can be varied, however, this may involve repositioning the plot in the program as well as changing two program cards. The user may have to redimension the storage associated with the loops preceding the plot in order to be sure the data computed is retained until the plot is called.

Equation No.	Equation
1.	$X_{(I+1)} = 1.1X_I$ FOR 86 VALUES FROM $X = 0.090909$
2 <sup>5</sup> .	$FT = 21.9 \times 10^6 - (1520/(T+273))$ kHz
3 <sup>5</sup> .	$AL = (1/8.68)(1/914.4) \left\{ \left[ (1.86 \times 10^{-2})(S)(FT)(FO)^2 / [(FT)^2 + (FO)^2] \right] + \left[ 2.68 \times 10^{-2}(FO)^2 / FT \right] + \left[ 0.1(FO)^2 / (1 + (FO)^2) \right] \right\} (1 - 6.33233 \times 10^5 D)$ NEPERS/METER
4 <sup>5</sup> .	$C = 1449.2 + 4.623T - 0.0546(T^2) + 1.391 (S-35) + 0.017D$ METERS/SECOND
5 <sup>6</sup> .	$NDIP = 10 \log_{10} (4\pi A (FO)^2 (10^3)^2 / C^2)$ DB
6.	$PADB = LSP - 70.8 - NDIP$ DB
7.	$PA = \text{ANTILOG} \left[ (1/10)(LSP-70.8-NDIP) \right]$ WATTS
8 <sup>1</sup> .	$NDIS = (NDIP) + 3 - 10 \log_{10} \left[ 1 + ((FO)/F)(2\pi AL)(RO) + X \right]$ DB

TABLE I

PROGRAM USAGE AND SAMPLE EXAMPLE

In order to use the program, the user must stack appropriately formatted data cards in a fixed order at the end of the program. There are six different types of cards. These cards will now be discussed in order from front to back of the stack.

The first type of card contains only one card and comes first in the data. It is formatted into 4 fields of one integer number per field. Each number must be right justified in a field width of five (Fortran V statement (I5)). The first field uses columns 1 through 5 and contains the number of F values. The second field uses columns 6 through 10 and contains the number of A values. The third field uses columns 11 through 15 and contains the number of LSS values. The fourth field uses columns 16 through 20 and contains the number of FO/F values plus 1. This arrangement of fields is summarized in Table 2.

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The second type of card contains only one card and it is the 2nd card in the data. It is formatted into 3 fields. Each field contains a number that is written in a floating point format which is right justified in a field width of 10 with a 4 decimal place accuracy (Fortran V statement (F10.4)). The first field uses columns 1 through 10 and contains the value for T. The second field uses columns 11 through 20 and contains the value for S. The third field uses columns 21 through 30 and contains the value for D. These fields are also summarized in Table 2.

The third through sixth type of cards may contain more than 1 card for each type but only one value for each card. Thus, one must use as many cards for each type as there are values associated with that type and the cards for each type must be grouped together. Each number is written in a floating point format which is right justified in a field width of 10 with a 5 decimal place accuracy (Fortran V statement (F10.5)). Each third type of card gives a value for F. Each fourth type of card gives a value for A. Each fifth type of card gives an input value for LSS (LSS1). Lastly, each sixth type of card gives a value for FO/F. Each of these field layouts are summarized in Table 2.

<u>Card Type</u>	<u>Card Columns</u>	<u>Fortran IV Format</u>	<u>Agreement</u>
1	1-5	I5	No. of F values
	6-10	I5	No. of A values
	11-15	I5	No. of LSS values
	16-20	I5	No. of FO/F values
2	1-10	F10.4	T in deg C
	11-20	F10.4	S in PPT
	21-30	F10.4	D in meters
3	1-10	F10.5	F in kHz
4	1-10	F10.5	A in sq. meters
5	1-10	F10.5	LSS in dB
6	1-10	F10.5	FO/F

TABLE 2  
DATA CARD FORMATS

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The use of this program requires the input of data from a program stored on tape in the NUSC New London Laboratory Univac 1108 files. This is tape U183. Different parameter plots may be made by simply changing the call to plot (Call Plot A) statements. There are two such plots in the program. The plot routine can be eliminated by removing the two call to plot cards which are located adjacent to each other in the program. The rest of the program should run and the table of results printed.

A sample example will now be discussed. Suppose we want to design a parametric sonar that has the following specifications:

$$LSS = 90 \text{ dB}/1\mu\text{bar-meter}$$

$$F = 3 \text{ kHz}$$

$$N_{DI} = 30 \text{ dB to } 35 \text{ dB}$$

and the power budget is such that we wish to minimize its consumption. Assume that the system will work in the ocean ( $S = 35 \text{ ppt}$ ) and that the system must be capable of operating in the winter ( $T = 7^\circ\text{C}$ ) on the surface ( $D = 0$ ). The data is programmed as shown in Figure 3. The tables of results are shown in Appendix B along with 3 sets of plots. Examination of the results shows several design possibilities all within the region of a dip in the PADB plots. If it were not possible to examine so large a quantity of points, the dip quite possibly would go unnoticed because there is a tendency for the unwitting designer to assume that increased stepdown ratio means increased power consumption. Apparently, this is not always true. When the desired points are isolated on the plots, the designer then can go to the tables and from them he can determine the design that gives the desired source level within the NDIS restrictions. The desired design for the sample example is the one underlined in the appropriate table of Appendix B and encircled on each of the associated PADB and NDIS vs FO/F plots. The selected design has the following parameters:

$$FO/F = 10$$

$$FO = 30 \text{ kHz}$$

$$LSP = 131.2 \text{ dB}/1\mu\text{bar-meter}$$

$$NDIP = 36.1 \text{ dB}$$

$$NDIS = 34.4 \text{ dB}$$

and PA = 267.1 watts/each primary frequency.

Other related quantities can be obtained from the data tables. For different applications these quantities may assume importance and thus are readily available if design tradeoffs become necessary.

#### CONCLUSION

A computer aided parametric sonar design program has been written for the UNIVAC 1108. This program allows the designer to take a given secondary source level (LSS), secondary frequency (F) and secondary directivity index (NDIS) and compute a range of possible parametric sonar designs that will satisfy his needs. Thus, the selection of sonar parameters is no longer limited by the difficulty of examining a range of possible parametric designs. The sonar designer can now construct a matrix of possible designs then base the final selection on which of these designs best fits the other systems parameters being considered. By means of computer aided design, literally hundreds of possible designs for a given situation can be investigated in a short time.

REFERENCES

1. Mellen, R. H. and M. B. Moffett, "A Model for Parametric Radiator Design," USN Journal of Underwater Acoustics, Vol. 22, No. 2, April 1972 (Unclassified).
2. Moffett, M. B., "Load Line Technique for Parametric Design," unpublished communication in 1972.
3. Gordon, R. L., "A Fortran V Plotting Routine for the Univac 1108 High Speed Printers," USL Tech Memo No. 2242-291-68, 25 July 1968 (Unclassified).
4. Goldstein, M., "On A numerical Integration in Parametric Sonar Research," NUSC Tech Memo No. PA4-268-71, 21 Oct 1971, (Unclassified).
5. Urick, R. J., "Principles of Underwater Sound for Engineers," McGraw Hill, Copyright 1967, pages 88-96.
6. "The Design and Construction of Magnetostriction Transducers," NDRC Div 6 Report Vcl. 13, dated 1946, p. 128.

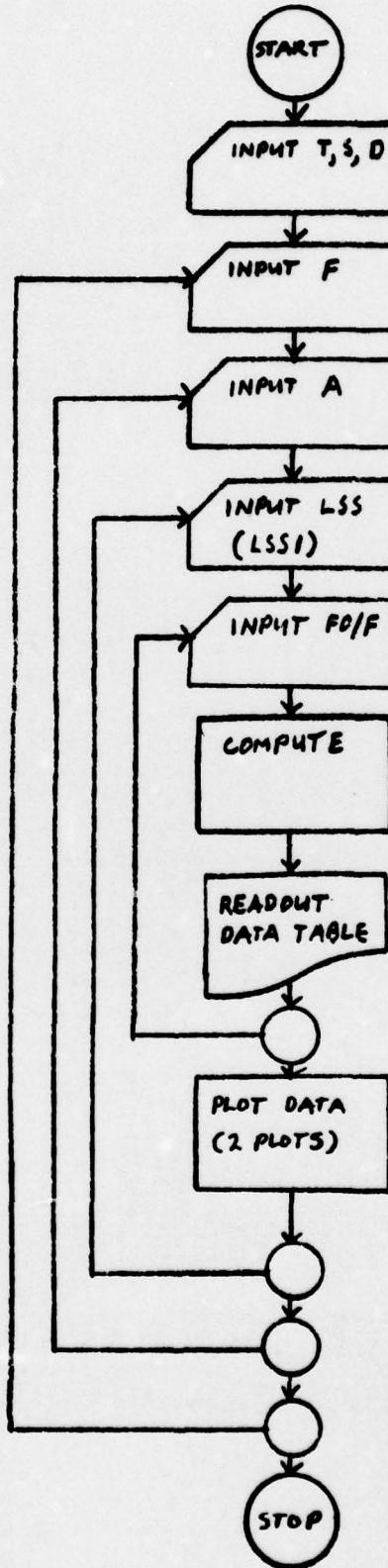


FIGURE 1

PARAMETRIC SONAR DESIGN,  
SIMPLIFIED FLOW CHART

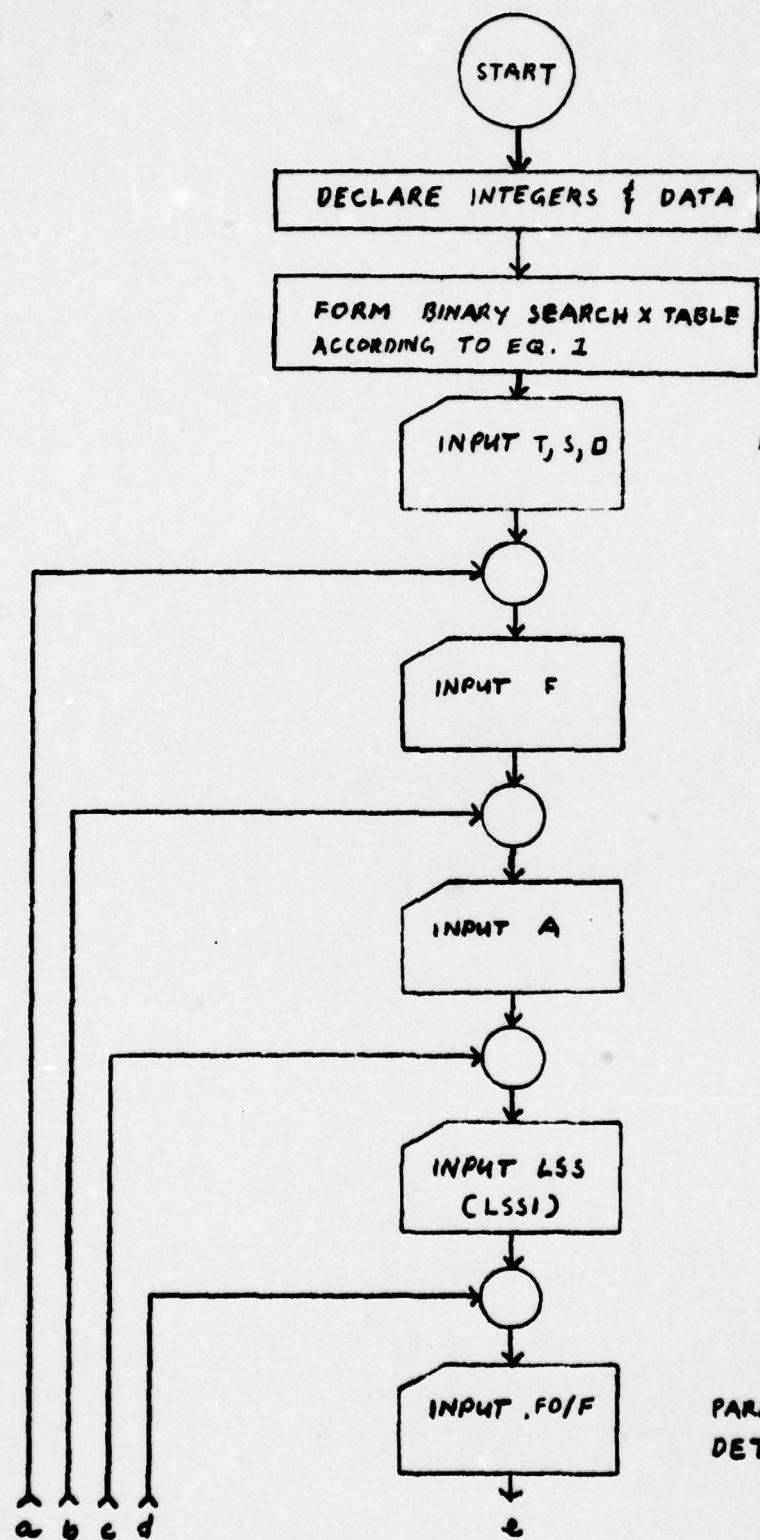


FIGURE 2

PARAMETRIC SONAR DESIGN,  
DETAILED FLOW CHART

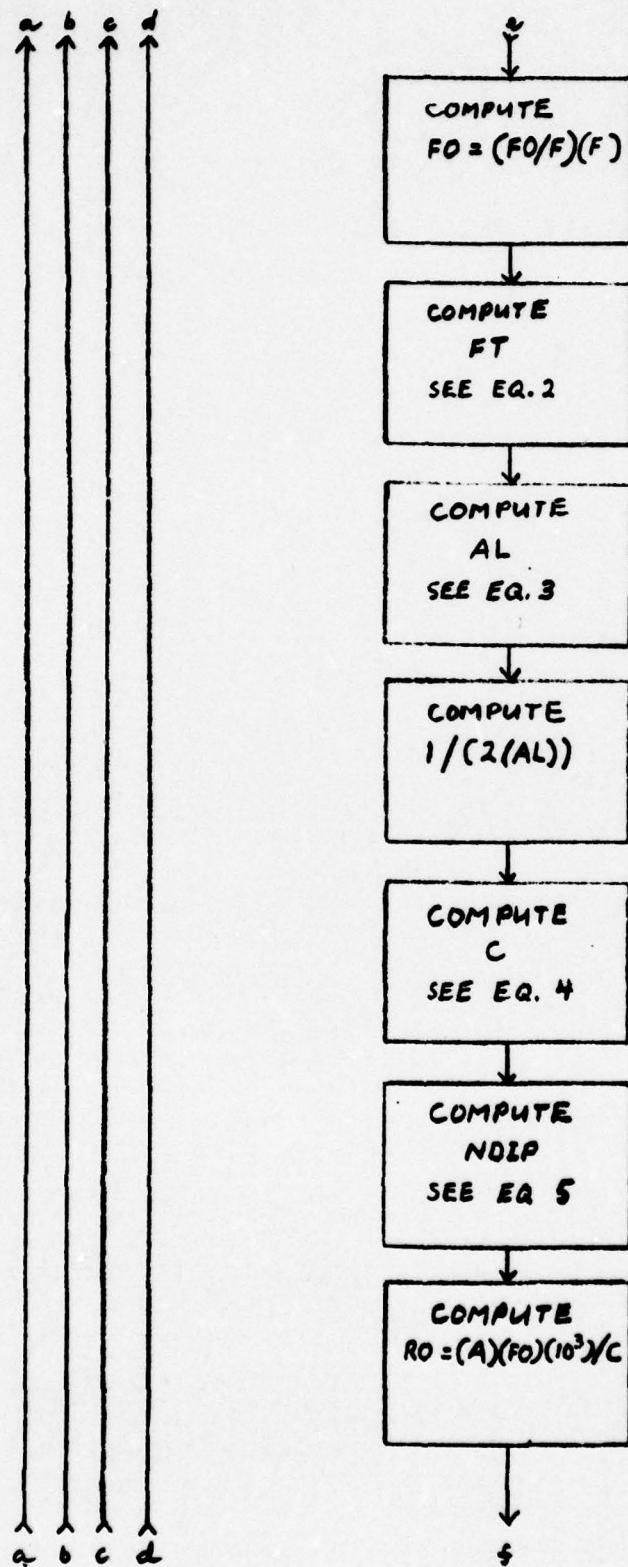


FIGURE 2 (CONT. 1)

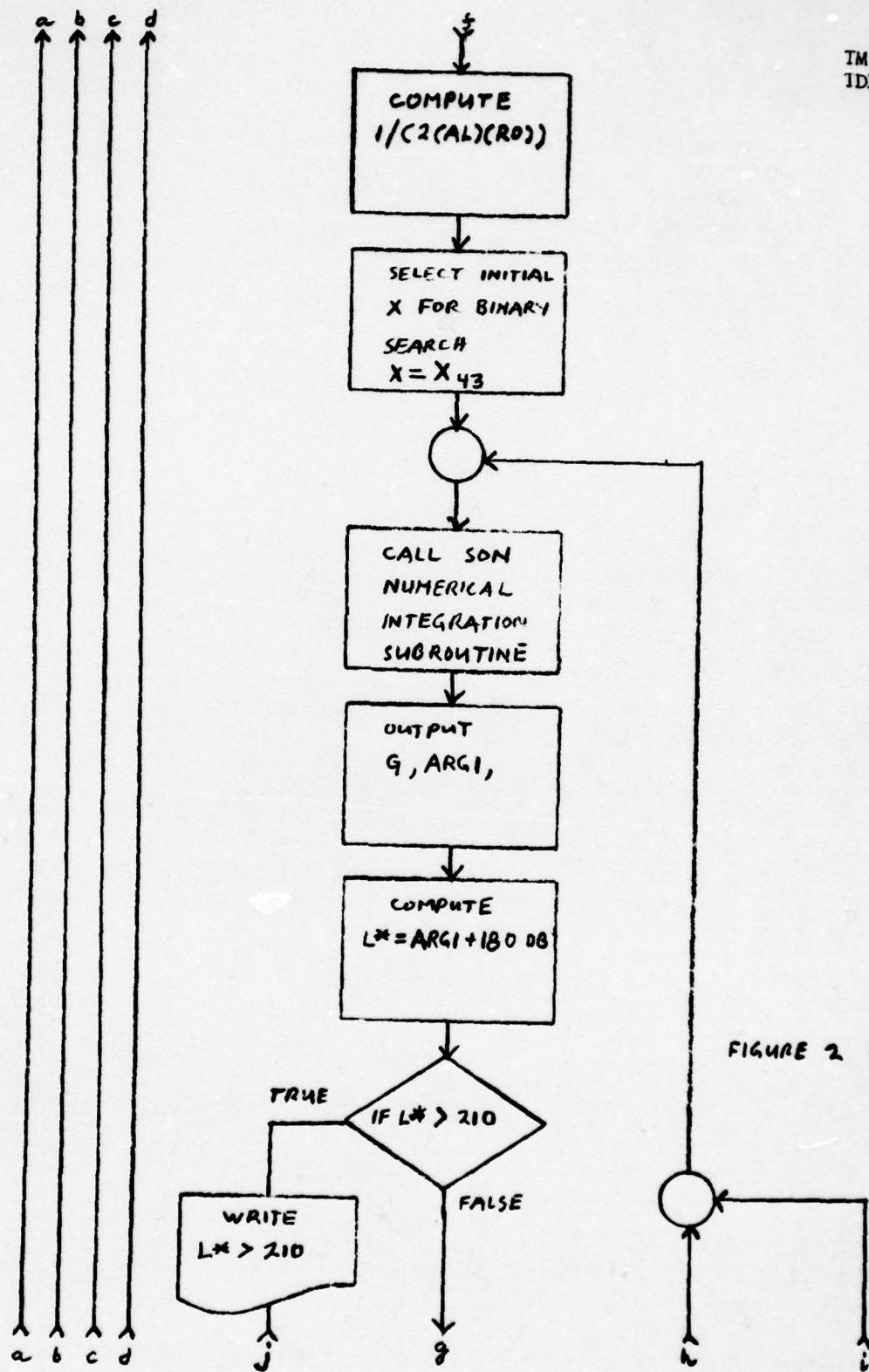


FIGURE 2 (CONT 2)

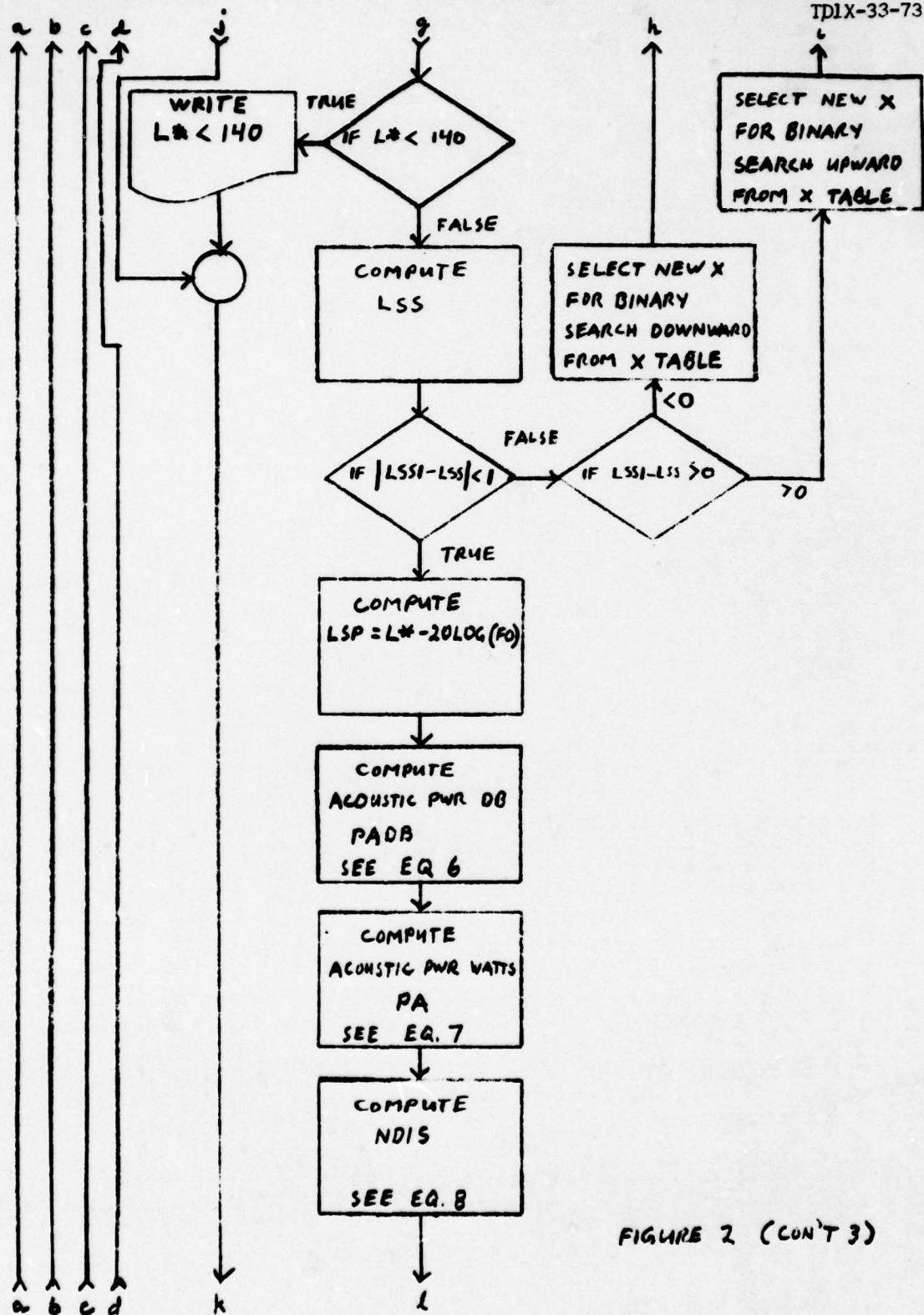


FIGURE 2 (CON'T 3)

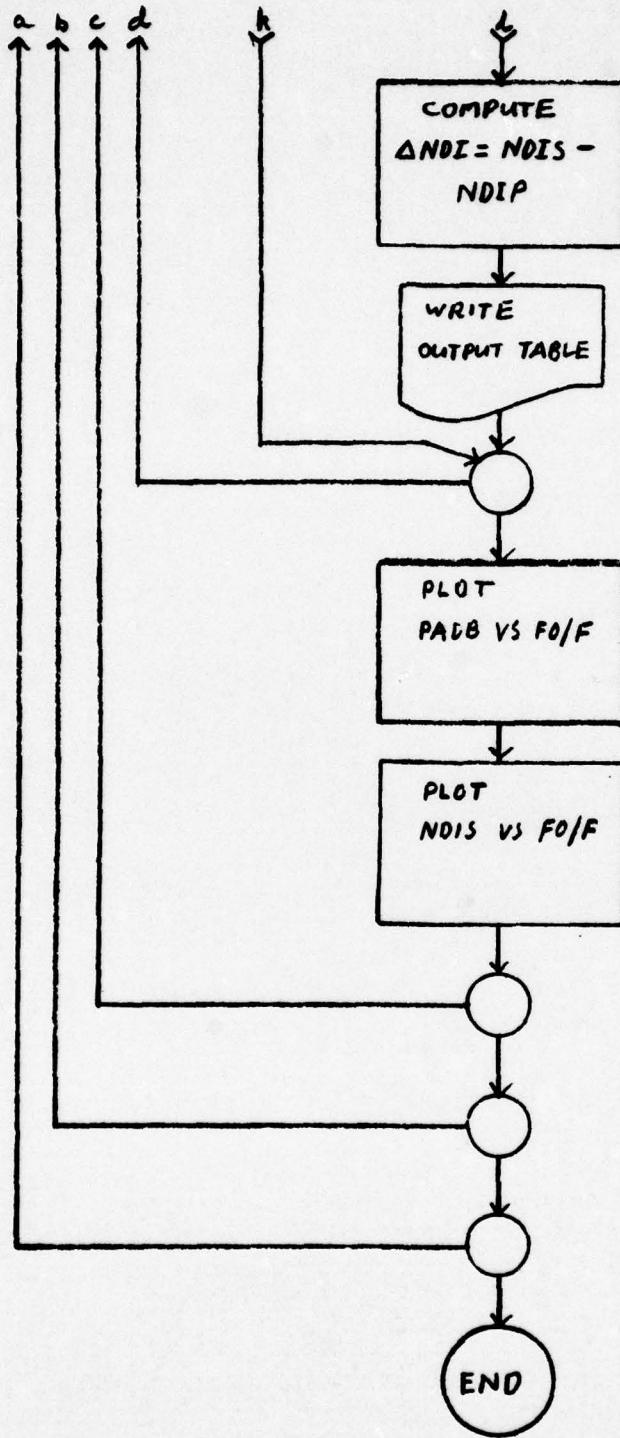


FIGURE 2 (CON'T. 4)

COLUMN NUMBER	
	30
	25
	20
1	15
1	10
1	5
	1

CARD 1  
CARD 2  
TYPE 3 CARDS  
TYPE 4 CARDS [

TYPE 5 CARDS  
TYPE 6 CARDS [

0 .  
0 .  
1 2 .  
3 5 .  
3 . 4 .  
7 . 3 .  
3 . 9 .  
1 9 .  
6 7 .  
2 5 .  
3 9 .  
1 0 .  
5 .  
7 . 5 .  
1 0 .  
1 2 . 5 .  
1 5 .  
2 0 .  
3 0 .  
4 0 .  
5 0 .  
7 0 .  
1 0 0 .

FIGURE 3

SAMPLE EXAMPLE DATA FORMAT

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APPENDIX A  
PROGRAM COMPILATION

The program compilation shown here is complete with subroutines except for the plot subroutine. That particular one was on tape and was not compiled as was the material that was put in by means of a deck of cards.

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FOR SUN, UNIVAC  
UNIVAC 1108 FORTRAN V LEVEL 2206 0026 (EXEC8 LEVEL E1201-0011)  
THIS COMPILED AT 14 JUN 73 AT 21:34:46.

21:34:46. 50

SUBROUTINE SUB ENTRY POINT 000067

STORAGE USE: CODE(11) 0001031 DATA(0) 00000201 BLANK COMMON(2) 0000000

COMMON BLOCKS:

0003 BLK 000010

EXTERNAL REFERENCES (BLOCK, NAME)

0004 USINH  
0005 DEXP  
0006 USQRT  
0007 NERHS

STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0003 D 0000000 AHO  
0003 D 0000006 X

0003 D 0000006 E 0003 D 0000002 GKDKO 0000 000012 TNJPS 0000 D 000000 T

00101	1*	SUBROUTINE SUB(A,J,H,F)
00103	2*	IMPLICIT DOUBLE PRECISION (A-H,O-Z)
00104	3*	COMMON/BLK/ARO,GKDKO,X,E
00105	4*	T=A*J*H
00106	5*	F=USINH(T)
00107	6*	T=1.000+((A*T)*2)/N_000
00110	7*	IF(AHO.GT.0.000) E=DEXP(-F*ARO)
00112	8*	F=F*E*2
00113	9*	F=(1.000+F)/(1.000+F*GKDKO*2)
00114	10*	FSE=IDSGRT(F)/T
00115	11*	RETURN
00116	12*	END

END OF COMPILEATION: NO DIAGNOSTICS.

FOR NOM-NOM  
UNIVAC 1108 FORTRAN V LEVEL 2206 0026 (EXEC6 LEVEL E1201-0011)  
THIS COMPILED IN GAS DUE ON 14 JULY 73 AT 21:34:47

TM No.  
TDIX-33-73  
2134:47. 40

SUBROUTINE NUM ENTRY POINTI 000246

STORAGE USED: LOLE(1) 0002751 DATA(0) 0000601 BLANK COMMON(2) 0000000

EXTERNAL REFERENCES (BLOCK, NAME)

0003	SUB
0004	NEXP1S
0005	NEXP2S
0006	NERR3S

STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0001	000071 1206	0001	000120 1306	0001	000033 4L	0000 D 000005 FN
0000 0	000000 M	0000	000031 INPS	0000 1	000015 TU	0000 I 000013 JI
0000 1	000002 K	0000 1	000014 L	0000 1	000011 M	0000 D 000007 SIG

```

C0101      1*      SUBROUTINE ROM(A,B,W,EPS,IV,NMX)
C0103      2*      DIMENSION A(NMX,NMX)
C0104      3*      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C0105      4*      H=U-A
C0106      5*      K=0
C0107      6*      CALL SUB(A,O,H,F)
C0110      7*      FN=F
C0111      8*      CALL SUB(A,1,H,F)
C0112      9*      N(1,1)=((F+FN)*H)/2.0D0
C0113     10*      4 K=N+1
C0114     11*      H=H/2.000
C0115     12*      SIG=0.000
C0116     13*      K=2*(K-1)
C0117     14*      DO 1 J=1,M
C0122     15*      J1=2*(J-1)
C0123     16*      CALL SUB(A,J1,H,F)
C0124     17*      1 SIG=SIG+F
C0126     18*      K(K+1,1)=N(K,1)/2.000+H*SIG
C0127     19*      DO 2 L=1,K
C0132     20*      2 U=K+1-L
C0133     21*      1 V=L+1
C0134     22*      2 N(JU,IV)=(4.000**((V-1)*W(IU+1,IV-1)-W(IU,IV-1))/(4.000**((IV-1)-1.
C0134     23*      1 W(IU,IV))=N(JU,IV)+(4.000**((V-1)*W(IU+1,IV-1)-W(IU,IV-1))/(4.000**((IV-1)-1.
C0136     24*      IF (ABS(W(IU,IV))-W(IU,IV-1)).LT.ABS(W(IU,IV))*EPS) RETURN
C0140     25*      GO TO 4
C0141     26*      END

```

A-3 . END OF COMPILATION: NO DIAGNOSTICS.

TM No.  
TDIX-33-73

FUN-SON-SUN  
UNIVAC 1108 FORTKAN V LEVEL 2206 0026 (EXECB LEVEL E1201-0011)  
THIS COMPIILATION WAS DONE ON 14 JUL 73 AT 21:34:48

21:34:40.364

SUBROUTINE SUN ENTRY POINT 000134

COMMON BLOCKS:

0003 BLK 000010

EXTERNAL REFERENCES (BLOCK, NAME)

0004	ROM
0005	DLOG
0006	DATAN
0007	DLOG10
0010	NEAR35

STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0001	000045	IL	0000 D 011612 A	0000 D 011620 ALN1	0003 D 000000 ARO
0003	0	C	0000 D 011610 EPS	0000 D 011622 FAC	0003 D 000002 GKDKO
0000	01650	INPS	0000 1 011624 IV	0000 D 000000 W	0003 D 000004 X

00101 1\* SUBROUTINE SON (RANKO,RKUKO,ARG,ANS,AIN,NMX)  
00103 2\* IMPLICIT DOUBLE PRECISION (A-H,O-Z)  
00104 3\* COMMON/BLK/ARO,GKDKO,X,E  
00105 4\* DIMENSION A(150,50),  
00106 5\* EPS=.5E-05  
00107 6\* AR0=0  
00110 7\* B=.40.0  
00111 8\* E=1.CD0  
00112 9\* ARU=0.0D0  
00113 10\* IF(RARU.GT.AR0) AR0=1.0D0/RARO  
00115 11\* RKUKO=1.0D0/RKUKO  
00116 12\* RKUKO=EKDU0\*.4\*2  
00117 13\* \*DIAGNOSTIC\* THE TEST FOR EQUALITY BETWEEN NON-INTEGERS MAY NOT BE MEANINGFUL.  
00117 13\* IF (RARU.EQ.0.0D0) GO TO 1  
00121 14\* ALI=DLOG (RKDKO)  
00122 15\* B=DLOG ((84.0D0+ALN1)\*RARO)  
00123 16\* 1 FACE=RKUKO\*(IX/2.0D0)  
00124 17\* CALL NUMA(B,W,EPs,IV,50)  
00125 18\* ALN=IV(1,IV)  
00126 19\* \*DIAGNOSTIC\* THE TEST FOR EQUALITY BETWEEN NON-INTEGERS MAY NOT BE MEANINGFUL.  
00126 19\* IF (RARO.EQ.0.0D0) ALN=ALN+2.0D0\*RKUKO\*(1.5707963267989D0-DATAN(10

00126	20*	1.0D0*X)/X
00130	21*	AIN=FAC*ALN
00131	22*	ANG=20.0D0*DLOG10(X)
00132	23*	AM5=20.0D0*DLOG10(AIN)

TM No.  
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00133      246      RETURN  
00134      250      ENU

END OF COMPIRATIONI      2 DIAGNOSTICS.

C-A

21:34:49.464

FOR SONAR'SONAR  
UNIVAC 1108 FORTRESS V LEVEL 2206 0026 (EXEC6 LEVEL E1201-0011)  
THIS COMPILED WAS DONE ON 14 JUN 73 AT 21:34:49

MAIN PROGRAM

STORAGE USED: CODE(11) 0010121 DATA(0) 0045361 BLANK COMMON(2) 0000000

COMMON BLOCKS:

0003 BLK 000010

EXTERNAL REFERENCES (BLOCK, NAME)

	SON	PLOTA	NKDUS	N1023	NEXPOS	N1013	N1011	AL0610	DLO610	DLO610	NSTOP3
0004											
0005	006023	100F	0000	004002	101F	0000	004003	102F	0000	004025	103F
0006	004262	105F	0000	004321	106F	0000	004346	107F	0000	004356	112F
0007	006426	114F	0001	000016	1176	0001	000523	13L	0001	000531	14L
0008	000149	156G	C001	000160	164G	0001	000557	17L	0001	000172	1726
0009	000573	200L	0001	000234	2066	0001	000671	210L	0001	000237	2116
0010	000177	220L	0001	000312	2366	0001	000430	2576	0001	000744	4L
0011	R 001130	A	0000 R	002424	ADM	0000 D	003410	AIN	0000 R	001750	ALPHA
0012	R 003244	ANS1	0000 D	003414	ARG	0000 R	003100	ARG1	0003 D	000000	ARO
0013	R 003753	D	0000 R	001274	WE1ND1	0000 R	004000	DUM	0003 D	000006	E
0014	F 014470	FU	0000 R	003764	FT	0003 D	00002	GDKD0	0000	000764	F
0015	I 003755	I8	0000 I	003756	IC	0000 I	003734	ICARD	0000 I	003754	IA
0016	I 003776	IJUM1	0000 I	003775	IJUM2	0000 I	003761	II	0000 I	003757	ID
0017	I 003770	IM1D	0000 I	003766	IM1N	0000 I	003771	IND	0000 I	003767	IMAX
0018	I 003777	ISAVE	C001	003762	J	0000 I	003763	JJ	0000 I	003775	IPRINT
0019	I 003742	KN2	0000 I	003743	KN3	0000 R	000620	LSP	0000 R	000000	KN1
0020	I 003744	N	0000 R	000454	NDIP	0000 R	000310	NOIS	0000 I	003765	NLX
0021	I 003746	N2	0000 I	003747	N3	0000 I	003750	N4	0000 R	002114	PA
0022	R 003748	P1	0000 R	004001	PY	0000 R	002570	RARO	0000 R	003420	RARO1
0023	D 003422	RFDF01	0000 R	001604	RO	0000 R	003752	S	0000 R	003751	T
0024	D 003412	X0	0000 D	003424	XX				0003 D	000004	X

STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0000	004242	104F	0000	004025	103F	0000	004242	104F
0001	004402	113F	0000	004356	112F	0000	004402	113F
0002	000541	15L	0001	000531	14L	0001	000541	15L
0003	000204	2006	0001	000172	1726	0001	000204	2006
0004	000247	2146	0001	000237	2116	0001	000247	2146
0005	000346	ANS	0000 D	003416	ANS	0000 R	003760	C
0006	000764	F	0000 R	000764	F	0000 R	000764	F
0007	003754	IA	0000 I	003757	ID	0000 I	003754	IA
0008	003774	ICONST	0000 I	003774	ICONST	0000 I	003774	ICONST
0009	003773	IIX	0000 I	003773	IIX	0000 I	003773	IIX
0010	003772	IOP7	0000 I	003772	IOP7	0000 I	003772	IOP7
0011	003741	KN1	0000 I	003740	KN	0000 I	003741	KN1
0012	000044	LSS1	0000 R	000000	LSS1	0000 R	000044	LSS1
0013	003745	N1	0000 I	003745	N1	0000 I	003745	N1
0014	002260	PADB	0000 R	002260	PADB	0000 R	002260	PADB
0015	002734	RFDFO	0000 R	002734	RFDFO	0000 R	002734	RFDFO

A-6

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00101   10
00103   20
00104   30
00105   40
00106   50
      REAL LSS1,LSS1,NOIS,NDIP,LSP
      PARAMETER LM1=100
      DIMENSION LSS1(LM1),LSP(LM1),LSS1(LM1),NOIS(LM1),F(LM1),A(LM1)
      DIMENSION WELND1(LM1),FO(LM1),PRO(LM1),ALPHA(LM1),NDIP(LM1),PA(LM1)
      DIMENSION PABD(LM1),RARO(LM1),RARO(LM1),RFDFO(LM1),ARG1(LM1),ANS1(LM1)

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6*      ALM1)
7*      DOUBLE PRECISION AHO,GRDKO,X,E,AIN,XO,ARG,ANS,RAR01,RFDF01
8*      DOUBLE PRECISION XX(ILMX)
9*      COMMON/BLK/ARG,GRDKO,X,E
10*      ICARD=3
11*      IPRINT=4
12*      PI=3.14159
13*      C
14*      CARU   COLUMNS   FORMAT   ARGUMENT
15*      C       1       1-5      15      KN= NO. OF F VALUES
16*      C       1       6-10     15      KN1= NO. OF A VALUES
17*      C       1       11-15    15      KN2= NO. OF LSS VALUES
18*      C       1       16-20    15      KN3= NO. OF FO/F VALUES +1
19*      C       2       1-10     F10.4
20*      C       2       1-10     F10.4
21*      C       2       1-10     F10.4
22*      C       2       1-10     F10.4
23*      C       2       21-30    F10.4
24*      C       2       21-30    F10.4
25*      C       3       1-10     F10.5
26*      C       3       1-10     F10.5
27*      C       4       1-10     F10.5
28*      C       5       1-10     F10.5
29*      C       6       1-10     F10.5
30*      C
31      X0=.909090910=-2
32*      DO 8  I=1,86
33*      X(I)=I*.1*40
34*      & X0=X(1)
35*      HEAD(ICARD,101) KN,KN1,KN2,KN3
36*      101 FOKHAT(145)
37*      NEKI
38*      NI=KNI
39*      N2=K12
40*      N3=K13
41*      N4=N3+1
42*      HFUF(1)=0.0
43*      PALB(1)=0.0
44*      NDIS(1)=0.0
45*      IF P0+EH IS IN EXCESS OF 100KW CHANGE SCALE OF PAOB PLOT
46*      C
47*      C
48*      PAUD(N4)=50.
49*      NI5(N4)=50.
50*      RFUFO(N4)=0.
51*      HEAD(ICARD,102) T,S,D
52*      102 FOKHAT(3F10,-4)
53*      HEAD(ICARD,100) (F1A),IA=1,N
54*      HEAD(ICARD,100) (A1B),IB=1,N1
55*      HEAD(ICARD,100) (LSS1(F1C),IC=1,N2)
56*      HEAD(ICARD,100) (RFDF01,I0=2,N3)
57*      C=1449.2+4.623*1.0546*(T+2)+1.391*(S-35.1)+.017 *D
58*      DU 1  I=1,KN
59*      DU 2  I=1,KN1
60*      DU 3  J=1,KN2
61*      WRITE(IPRINT,107)
62*      WRITE(IPRINT,105)
63*      WRITE(IPRINT,104)
A-7  60220,
620
630

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TM No.  
TDIX-33-73

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610      WRITE(IPRI,J,104) T,DS,C,A(11)
        WRITE(IPRI,J,105)
650      DO 9 JJEZ=AN3
660      F0(JJ)=RFU(O(JJ))*F(11)
670      E5(I0,J,0,J)=F0(JJ)
680      F1=I0.*y+10.*x/(1520.*((T+273.)) )
690      ALPHA(JJJ)=(1./B.*68)*((1./914.*S184.*01065*(SAFT)*(E
700      101,JJ)+((F1*x2+F0(JJ)*x2)+.0268*F0(JJ)*x2)/FT)*
710      2*x2/(1.+F0(JJ)*x2))
720      NJP(JJJ)=10.*AL0610((N,*PI*A(11)*E*x2)/C*x2)
730      R0(JJ)=(A((L1)*F0(JJJ)*x10.***3))/C
740      K40(JJJ)=1.0/(12.*ALPHA(JJ)*R0(JJ))
750      A0M(JJJ)=1.0/(12.*ALPHA(JJ))
760      NJZ=66
770
00251    780
00252    790
00253    800
00254    810
00255    820
00256    830
00261    840
00262    850
00263    860
00264    870
00265    880
00266    890
00267    900
00270    910
00272    920
00274    930
00275    940
00277    950
00301    960
00302    970
00303    980
00306    990
00307    1000
00310   1010
00311   1020
00312   1030
00313   1040
00314   1050
00315   1060
00316   1070
00317   1080
00322   1090
00323   1100
00324   1110
00325   1120
00326   1130
00327   1140
00330   1150
00331   1160
00332   1170
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00335   1190
00336   1200
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1220
00340      123*          PA(J,J)=10.*#DUM
00341      123*          NDIS(J,J)=(NDIP(J,J)+3.)-10.*AL0610(1.+IRFDFO(J,J))*(2.*PI*A(LPHA(J,J))*R
00341      124*          1U(J,J)+X(J,J)
00342      125*          UELN(J,J)=NDIS(J,J)-NDIP(J,J)
00343      126*          WITL(IPKINT106) F(1),PAUB(J,J),RFDF0(J,J),F0(J,J),ALPHA(J,J),ADUM(J,J)
00343      127*          1J,RO(J,J),NDIP(J,J),LSP(J,J),LSS(J,J),ANS1(J,J),PA(J,J)
00343      128*          2J,NDIS(J,J),DELNDI(J,J)
00343      129*          GO TO 4
00345      130*          210 LSp(J,J)=0..0
00366      130*          PAUB(J,J)=0..0
00367      131*          NDIS(J,J)=0..0
00370      132*          NDIS(J,J)=0..0
00371      133*          WHIT(IPRINT,112) F(1),PAUB(J,J),RFDF0(J,J),F0(J,J),ALPHA(J,J),ADUM(J,J)
00371      134*          1J,RO(J,J),NDIP(J,J),LSS(J,J),ANS1(J,J),ANG1(J,J),ANG2(J,J)
00410      135*          220 LSp(J,J)=0..0
00412      137*          PAUB(J,J)=0..0
00413      138*          NDIS(J,J)=0..0
00414      139*          WRITE(IPRINT,113) F(1),PAUB(J,J),RFDF0(J,J),F0(J,J),ALPHA(J,J),ADUM(J,J)
00414      140*          1J,RO(J,J),NDIP(J,J),LSS(J,J),LSP(J,J),ANG1(J,J),ANG2(J,J)
00433      141*          4 CONTINUE
00433      142*          C   THE PLOT ROUTINES ARE ON TAPE U183
00433      143*          C
00433      144*          C
00435      145*          CALL PLOTA(RFDFO,PAOB,PY,N4,1H*,1J,'PADB VS FO/F',2,IPRINT)
00436      146*          CALL PLOTA(RFDFO,NUIS,PY,N4,1H*,1J,'NDIS VS FO/F',2,IPRINT)
00437      147*          3 CONTINUE
00441      148*          2 CONTINUE
00441      149*          1 CONTINUE
00443      149*          1 CONTINUE
00445      150*          100 FORMAT(F10.5)
00446      151*          103 FORMAT(50X,'T= WATER TEMPERATURE (DEGREES C)')
00446      152*          1//50X,'D= PROJECTOR DEPTH (METERS)',0
00446      153*          3//50X,'S= SALINITY (PPT)',0
00446      154*          4//50X,'F= SECONDARY FREQUENCY (KHZ)',0
00446      155*          2//50X,'A= PROJECTOR AREA (.50. METERS)',0
00446      156*          6//50X,'FUR= DOWNSHIFT RATIO',0
00446      157*          7//50X,'FO= PRIMARY FREQUENCY (KHZ)',0
00446      158*          8//50X,'AL= AUSSHIFT CONSTANT (NEPERS/METER)',0
00446      159*          9//50X,'1/2AL= REACTION LIMIT (METERS)',0
00446      160*          1//50X,'RD= RAYLEIGH DISTANCE (METERS)',0
00446      161*          2//50X,'NDAP= DIRECTIVITY INDEX-PRIMARY (DB)',0
00446      162*          3//50X,'LSS= SECONDARY SOURCE LEVEL (DB/MICROBAR-METER)',0
00446      163*          4//50X,'LSP= PRIMARY SOURCE LEVEL (DB/MICROBAR-METER)',0
00446      164*          5//50X,'L= SCLED SOURCE LEVEL (DB/MICROBAR-METER-KHZ)',0
00446      165*          6//50X,'GZ= PARAMETEN GAIN (DB)',0
00446      166*          7//50X,'PKE= ACOUSTIC POWER PER TONE (WATTS)',0
00446      167*          8//50X,'AND1= DIRECTIVITY GAIN (DB)',0
00446      168*          9//50X,'HUISE= SECONDARY DIRECTIVITY INDEX (DB)',0
00446      169*          1//50X,'PAUD= ACOUSTIC POWER (DB/WATT) PER EACH PRIMARY TONE',0
00447      170*          104 FORMAT(//5A,'T= ',F5.0,'/5X,'ID= ',FB,1./5X,'SE ',F4.0,'/5X,'C= ',0
00447      171*          1F0,0.,/5X,'A= ',F9.4)
00450      172*          105 FORMAT(5X,'F= ',BX,'PAOB= ',3X,'FO/F',5X,'AL= ',5X,'/2AL',5X,R
00450      173*          1074X,'1/2ALR= ',1X,'NDIP= ',3X,'L= ',5X,'/5X,'PA(2WATS)',0
00450      174*          106 FORMAT(F9.,3JX,F5,1JX,F7,2JX,F0,3JX,F9,6JX,F6,1JX,F5,1JX,F5,1JX,F5,1)
00451      175*          11JX,F5,1JX,F6,1JX,F6,1JX,F6,1JX,F5,1JX,F5,1JX,F5,1JX,F5,1)
00451      176*          107 FORMAT(49X,'PARAMETRIC SONAR FORMULA AND ANALYSIS')
00452      177*          112 FORMAT(F9.,3JX,F5,1JX,F7,2JX,F0,3JX,F9,6JX,F7,0,1X,F8,
00453      178*          11JX,F5,1JX,F6,1JX,F6,1JX,F6,1JX,F5,1JX,F5,1JX,F5,1JX,F5,1)
00453      179*          11JX,F5,1JX,F6,1JX,F6,1JX,F6,1JX,F5,1JX,F5,1JX,F5,1JX,F5,1)

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TM No.  
TDIX-33-73

00434	160*	113. FOMMATE(F9.2+3X,F5.1,1X,F7.2+1X,F9.6+1X,F7.0+1X,F7.0+1X,F8.
00456	161*	114. F5.1,1X,F6.1,1X,F6.1,1X,F6.1,1X,F5.1,10X, 'Ls < 140.,'
00455	162*	114. FOMMATE(1M1)
00456	163*	STOP
00457	164*	END

END OF COMMUNICATION; NO DISAGREEMENT.

TM No.  
TD1X-33-73

APPENDIX B  
SAMPLE EXAMPLE READOUT

The sample example tables and plots are shown here. These are as they appear on line out of the high speed printer associated with the computer.

TM No.  
IDIX-33-73

PARAMETRIC SONAR DESIGN AND ANALYSIS

T= WATER TEMPERATURE (DEGREES C)

U= PROJECTOR DEPTH (METERS)

S= SALINITY (PPT)

F= SECONDARY FREQUENCY (KHZ)

A= PROJECTOR AREA (SQ. METERS)

F<sub>0</sub>/F<sub>2</sub>= DOWNSHIFT RATIO

F<sub>0</sub>= PRIMARY FREQUENCY (KHZ)

A<sub>L</sub>= ABSORPTION CONSTANT (NEPERS/METER)

1/2A<sub>L</sub>= REACTION LIMIT (METERS)

R<sub>0</sub>= RAYLEIGH DISTANCE (METERS)

NDIP= DIRECTIVITY INDEX-PRIMARY (DB)

L<sub>SS</sub>= SECONDARY SOURCE LEVEL (DB/MICROBAR-METER)

L<sub>SP</sub>= PRIMARY SOURCE LEVEL (DB/MICROBAR-METER)

L<sub>s</sub>= SCALED SOURCE LEVEL (DB/MICROBAR-METER-KHZ)

G= PARAMETER GAIN (UB)

P<sub>A</sub>= ACOUSTIC POWER PER TONE (WATTS)

AND<sub>1</sub>= DIRECTIVITY GAIN (UB)

NDIS= SECONDARY DIRECTIVITY INDEX (DB)

PABB= ACOUSTIC POWER (DB/WATT) PER EACH PRIMARY TONE

T3 7.

D3 .0

S3 35.

C3 1479.

A2	.1968	FU/FU	F0	AL	1/2AL	RO	1/2ALHU	MJIP	LSS	LSP	L*	P(AWATTS) NOIS	AMBI
F.	PAUW												
3.000	30.7	5.00	15.000	.000241	2079.	20	1043.5	20.0	69.4	125.4	149.1	-36.2	1165.2 26.4
3.000	29.5	7.50	22.500	.000506	989.	30	330.5	27.6	91.0	127.9	156.9	-36.9	689.0 26.6
3.000	27.6	10.00	30.000	.000646	591.	40	146.3	30.1	69.8	126.7	156.2	-36.9	603.0 26.3
3.000	27.2	12.50	37.500	.001237	404.	50	61.1	32.0	69.7	130.0	161.5	-40.3	529.4 30.3
3.000	27.4	15.00	45.000	.001657	302.	60	50.5	33.6	90.2	131.0	164.8	-41.5	547.3 30.0
3.000	26.2	20.00	60.000	.002510	199.	60	25.0	36.1	90.5	135.1	170.6	-44.6	657.6 29.0
3.000	31.1	30.00	90.000	.004021	124.	120	10.4	39.6	89.2	141.5	180.6	-52.3	2279.5 22.4
3.000	36.0	40.00	120.000	.005166	98.	160	6.1	42.1	89.5	148.9	190.5	-57.4	3987.5 22.2
3.000	36.4	50.00	150.000	.006209	82.	200	4.1	44.0	89.4	153.6	197.1	-64.2	7504.9 21.0
3.000	42.0	70.00	210.000	.007633	65.	200	2.3	47.0	89.3	159.3	206.2	-70.5	18902.7 20.1
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3.000	26.4	5.00	15.000	.000241	2079.	6.	260.9	30.1	90.2	127.2	150.8	-37.0	433.9	32.2
3.000	25.1	7.50	22.500	.000506	968.	12.	82.7	33.6	90.7	129.5	156.6	-38.8	325.5	34.1
3.000	24.3	10.00	30.000	.000646	591.	16.	37.1	36.1	89.9	131.2	160.7	-41.2	267.1	34.4
3.000	24.5		37.500	.001237	404.	20.	20.3	38.0	90.1	133.4	166.8	-43.3	283.8	33.9
3.000	25.3	15.00	45.000	.001957	302.	24.	12.6	39.6	90.7	135.9	169.0	-45.2	355.0	33.1
3.000	27.1		20.00	.02510	199.	32.	6.3	42.1	90.2	140.0	175.6	-49.9	516.1	31.5
3.000	30.6		30.00	.074021	124.	48.	2.6	45.6	89.6	147.3	186.4	-57.7	1215.0	-10.6
3.000	34.4		40.00	.05166	96.	64.	1.5	48.1	90.3	153.1	194.6	-92.8	2586.3	-17.0
3.000	35.2		50.00	.026109	82.	80.	1.0	50.1	89.5	156.1	199.6	-66.6	3324.7	-21.6
3.000	36.5	70.00	210.00	.007653	65.	112.	.6	53.0	90.4	162.3	208.7	-71.8	7044.9	-25.0
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